

The Now Improved Theodolite.

The Universal Dial.



The Double Level.

Mathematical Instruments
 Contrived & Made in Metal, Ivory or Wood, according to the latest
 Observations of Philosophers and Practitioners of Mathematical
 Arts, by Tho. Heath at the Hercules next the Fountain in St. Strand London.
 With Books of their Use. Tho. Platt sculp.

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THE
Practical Surveyor:

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Measuring, Mapping and Adorning
All SORTS of
LANDS and WATERS,
By the Several

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to be ACCURATE, as well as EXPEDITIOUS.

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GENTLEMAN'S SEAT. Also, the Use thereof in LEVELLING,
Measuring Timber Standing; and, by a Sliding Rule im-
proved, all Timbers, Shrubs, &c.

Likewise, The Description and Use of an UNIVERSAL DIAL,
whereby the Hour of the Day, SUN'S *Azimuth*, *Altitude*,
&c. with the Variation of the COMPASS, is readily observ'd,
to the greatest Exactness.

By JOHN HAMMOND.

The SECOND EDITION,

Carefully Revised, Corrected and Enlarged;

With the ADDITION of an APPENDIX, containing
a New, Easy, and most Accurate Method of Surveying,
Plotting, and Casting up, never till now made Public.

By SAMUEL WARNER.

L O N D O N :

Printed for T. HEATH, Mathematical-Instrument-Maker, at
the *Hercules*, next the *Fountain-Tavern* in the Strand.

M.DCC.XXXI.



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PREFACE.



THE Design of the following TRACT, is to shew, as it were by Inspection, the whole Business of a *Land-Surveyor*; without the Confusion of useless Curiosities, or the Omission of any *Problems* necessary to the Practice: And in so plain, tho' concise a Manner, that one of a common Capacity, may hereby, together with a little Reflection on the Instruments for

this Purpose used, acquaint himself with this useful Art.

It is extracted from those Writers, who have been look'd upon as good Judges, as well as frequent and ingenious Professors; and it is hop'd, not without Reason, That it will answer the End for which it is designed.

First, Here are some *Geometrical Problems*, absolutely necessary to be known by every Person who undertakes Surveying.

Then, a particular and very exact Description of the several Instruments: And a just Comparison of them together; particularly the various Sorts of *Theodolites*: With due Directions and Cautions in their Management, according to their several Kinds; in order to prevent

prevent Errors and Mistakes, as well in the taking Observations (and correcting before we leave the Field) as in plotting and laying down the Draught.

Thirdly, An easy Way to cast up the Content of any Land, whether bounded by strait or irregular Sides, and that often without marking or staining the Draught, or drawing one single Line.

The Use of the THEODOLITE, as now improved, by a large Example, shewing its Advantages, above all other Instruments, heretofore used, in surveying large Parcels of Lands of different Kinds; interspers'd with many Varieties often met with in the Practice. And a very regular and easy Way of keeping and ordering of the

Field-Book, to prevent the Faults incident to the Memory ; with full and plain Directions to plot by the same : From Mr. *Cunn's* Appendix.

Afterwards follows the Use of this THEODOLITE, in allowing for Ascents and Descents, by finding the Horizontal Lines ; absolutely necessary to the due Performance of a just Survey. And this BY INSPECTION, WITHOUT ANY CALCULATION. Together with its Application to the Measuring of Heights, with the same Ease.

Then the Practical Measurement, as well of Timber, whether round or squared, equal or unequal, as of Stone, &c. by the *Sliding Rule*, as now improved, and fitted for all Timbers, tho' never so large, as well as the smallest

smallest Shrubs or Sticks, that are often sold by Measure. And this even BY ONE SETTING OF THE RULE, without any other previous Preparation, than taking the Dimensions : In many Cases, scarce before practised.

Another Use of this NEW THEODOLITE, is, that in all Positions of the Eye, it is fitted to take the Perspective Appearance of Houses, Gardens, Fortifications, &c. with or without approaching the Object, and without measuring any one single Length.

Also a Method to Survey and Plat those Sands, that are always under Water, by the same Instrument.

Lastly, The Method to adjust, and use the Water Level ; with due Precaution therein.

Moreover, that nothing might be wanting to render this Treatise perfect for the Practitioners Use, here is added (by way of *Appendix* to this *Second Edition*) a more particular Description of the *Improved Theodolite*, with a new Method of using it in taking the Observations in the Field ; whereby an Error may be more readily discovered and prevented, than by any former Ways hitherto used ; with an Example of the *Field-Book* of Part of an actual Survey taken thereby. Likewise, a full Explanation of the Manner of laying down those Observations from one Centre, so as to avoid the Faults which arise from protracting Angle by Angle. As also how to reduce irregular Figures to Triangles, with the Application thereof in casting up the Contents of the forementioned Example.

ADVER-



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stuffs, Nocturnals, *Gunter's*, Sea-Compasses,
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ESTATES in *Land or Houses* are faithfully Surveyed and Plotted by the most approved Instruments and Methods, and FAIR MAPS thereof accurately delineated. Also, Terrars or Survey-Books drawn therefrom; shewing the Quantity, Quality, and Value of what each Tenant holds, &c.

By SAM. WARNER,

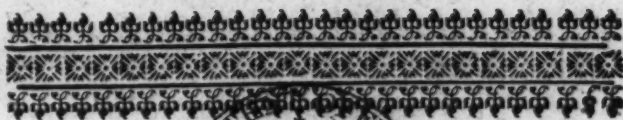
*At the Two Civet-Cats, near the
Rose-Tavern, without Temple-
Bar: Where GENTLEMEN may
be instructed in the Practice of
SURVEYING, or in any other
Branch of Theoretical and Practical
MATHEMATICKS.*

ARTICLE I

SECTION 1
All legislative Powers herein granted shall be vested in a Congress of the United States, which shall consist of a Senate and House of Representatives.
SECTION 2
The House of Representatives shall be composed of Members chosen every second Year by the People of the several States, and the Electors in each State shall have the Qualifications requisite for Electors of the most numerous Branch of the State Legislature.
No Person shall be a Representative who shall not, when elected, have seven Years Residence in the United States; and, when elected, shall be, when elected, seven Years old.

SECTION 3

Representatives and direct Taxes shall be apportioned among the several States which may be included within this Union, according to their respective Numbers, which shall be determined by adding to the whole Number of free Persons, including those bound to Service for a Year, and the Indians not taxed, three fifths of all other Persons. The actual Enumeration shall be made within three Years after the first Meeting of the Congress of the United States, and in every subsequent Year as the Congress may direct. But no Enumeration shall be made in any State until the next Census of the United States.
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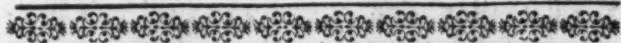
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THE



T H E

Practical Surveyor.



S E C T. I.

Of MENSURATION *in general, with*
the most necessary GEOMETRICAL
 PROBLEMS.



O Measure, in the general Sense that *Geometricians* use the Word, is, to assume any certain Quantity, and express the Proportion which other similar Quantities bear thereto: But in the common Acceptation, to Measure, is, to apply some certain known Quantity pitched upon for a Standard, and thereby to determine the precise Extent, Quantity or Capacity of any thing of the same Kind. Thus :

B

The

The Measure of a Line is found by applying the lineal Inch, Foot, Yard, Pole, &c. thereto, in order to discover its Length; the doing of which is called *Longimetry*.

The Measure of a Superficies is obtained by the Application of the superficial or square Inch, Foot, Yard, Pole, Acre, &c. thereby to determine its Area or Content; the Method of doing which is called *Planimetry*, whereof Surveying of Land is a Part; and of this the following Pages chiefly treat.

The Measure of a Solid is had by comparing it with the solid or cubic Inch, Foot, Yard, Gallon, &c. thereby to find its Capacity or solid Content, which is called *Stereometry*, and comprehends the measuring of Timber, Stone, &c.

Now, though it cannot be supposed that any Person, who is wholly ignorant of the first Principles of *Geometry*, should expect to become a compleat Surveyor by barely reading this Book, whence it might seem altogether unnecessary to insert the common Definitions and Problems; yet, in order to refresh the Reader's Memory, when other Books are not at hand, it was thought not improper to lay down some few of the most popular *Problems*; and such are those that follow.



PROB.

P R O B. I.

Upon a given right Line, to erect another right Line, which shall be perpendicular to the right Line given.

THE right Line given is A B (*Fig. 1.*) upon which, from the Point E it is required to erect the Perpendicular E H.

Opening your Compasses at Pleasure to any convenient Distance, place one Foot in the assigned Point E, and with the other make the Marks C and D, equi-distant on each Side the given Point E. Then opening your Compasses again to any other convenient Distance, wider than the former, place one Foot in C, and with the other describe the Arch G G; also (the Compasses remaining at the same Distance) place one Foot in the Point D, and with the other describe the Arch F F: Then from the Point H, where these two Arches intersect or cut each other, draw the right Line H E, and it will be a Perpendicular to the given right Line A B; which was the Thing required to be done.



P R O B. II.

To erect a Perpendicular upon the End of a right Line given.

LET A B (*Fig. 2.*) be a right Line given, and from the End thereof, at B, let it be required to erect the Perpendicular B F.

First, Your Compasses being open'd at any convenient Distance, place one Foot in B, and with the other make the Mark C, the Compass Point resting in C; with the other Foot make the Mark D, in the given Line A B; lay a Ruler from D to C, and draw the Line D E, making C E equal to C D. *Lastly*, from B, through E, draw the Line B F, which will be the Perpendicular required.

P R O B. III.

To divide a given right Line into Two equal Parts.

LET C B (*Fig. 3.*) be a right Line given, to be divided into Two equal Parts.

From the Extremes B and C, with any Distance greater than half the given Line, describe Arches above and below, cutting one another in the Points D and F: Draw D F, and it will divide A B into Two equal Parts in H, as required.

P R O B.

P R O B. IV.

To let fall a Perpendicular from any Point assigned, upon a right Line given.

LET the Point given (*Fig. 4.*) be C, from which Point it is required to draw a right Line, which shall be perpendicular to the given right Line A B.

First, From the given Point C, to the Line A B, draw an occult Line at Pleasure, as C E, which divide into Two equal Parts in the Point D: Then placing one Foot of the Compasses on the Point D, with the Distance D C, describe the Semicircle C F E, cutting the given Line A B in the Point F. *Lastly*, From the Point C, draw the right Line C F, and it shall be the Perpendicular to the given Line A B, which was required.

P R O B. V.

To make an Angle equal to an Angle given.

LET the Angle given be A C B (*Fig. 5.*) and let it be required to make another Angle equal thereunto.

First, Draw the Line E F at Pleasure; then on the Angular Point C, as a Center, with any convenient Distance describe the Ark A B, between the Legs of the Angle given; also upon the Point F, with the same Distance describe the Ark D E: Then take

with your Compasses the Distance A B, and set the same Distance from E to D. *Lastly*, Draw the Line D F, so shall the Angle D F E be equal to the given Angle A C B.

P R O B. VI.

At a given Distance, to draw a right Line parallel to a right Line given.

LET the Line given be A B, (Fig. 6.) unto which it is required to draw another right Line parallel, at the Distance M N.

First, Open your Compasses to the Distance M N, then placing one Foot in A, with the other describe the Ark C; also place one Foot in B, and with the other describe the Ark D. *Lastly*, Draw the Line C D, so that it may only touch the Arks C and D; so shall the Line C D be parallel to the Line A B, and at the Distance M N, as was required.

P R O B. VII.

A right Line being given, to draw another right Line parallel thereunto, which shall also pass through a Point assigned.

LET A B (Fig. 7.) be a Line given, and let it be required to draw another Line parallel thereunto, which shall pass through the given Point C.

First,

First, Take with your Compasses the Distance from A to C, and placing one Foot thereof in B, with the other describe the Ark D E; then take in your Compasses the Distance A B, and placing one Foot in the Point C, with the other describe the Ark F G, crossing the former Ark D E in the Point H. *Lastly*, Draw the Line C H, and it shall be parallel to A B.

These two last PROBLEMS may be more easily performed by a parallel Ruler.

P R O B. VIII.

To divide a given right Line into any Number of equal Parts.

LET A B (*Fig. 8.*) be a right Line given, and let it be required to divide the same into five equal Parts.

First, From the End of the given Line A, draw the Line A C, making any Angle; then from the other End of the given Line B, draw the Line B D parallel to A C, (or make the Angle A B D equal to the Angle C A B) then upon the Lines A C and B D, set off any four equal Parts (which is one less than the Number of Parts into which the Line is to be divided) on each Line, as 1, 2, 3, 4; then draw Lines from 1 to 4, from 2 to 3, from 3 to 2, and from 4 to 1, which Lines, crossing the given Line A B, shall divide it into five equal Parts, as was required.

P R O B. IX.

Any three right Lines being given, provided the two shortest taken together be longer than the third, to make thereof a Triangle.

LET it be required to make a Triangle of the three Lines C, B, and A, (*Fig. 9.*) the two shortest whereof, *viz.* C and B taken together, are longer than the third Line A.

First, Draw the Line D E equal to the given Line B, then take with your Compasses the Line A, and setting one Foot in E, with the other describe the Arch H G ; also take the given Line C in your Compasses, and placing one Foot in D, with the other describe the Arch K F, cutting the former Arch H G in the Point O. *Lastly*, If from the Point O, you draw the Lines O E and O D, there will be formed the Triangle O D E, whose Sides shall be equal to the three given Lines, A, B, C.

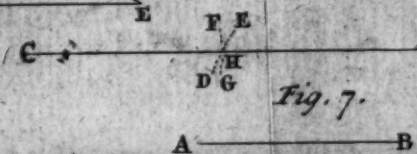
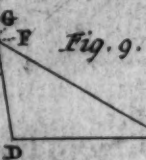
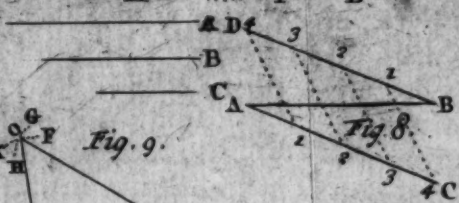
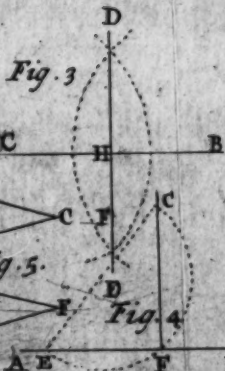
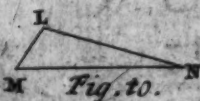
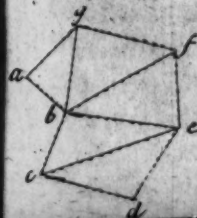
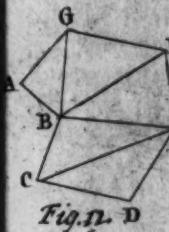
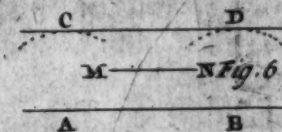
In like manner a Triangle *l m n* may be made equal to another given L M N. *See Fig. 10.*

Also any rectilinear Figure *a b c d e f g*, equal to any other rectilinear Figure A B C D E F G, by making the Triangles *a b g*, *b g f*, *b f e*, *b c e*, *c e d*; respectively equal to the Triangles A B G, B G F, B F E, B C E, C E D. *See Fig. 11.*

S E C T.



Pag. 8





Of INSTRUMENTS *used in Sur-
veying Land.*



INSTRUMENTS used in Sur-
veying are, either to measure, or
lay down the Lengths of Lines, or
their Positions.

The most proper Instruments for measuring Lengths, in Towns, Streets, or any other Buildings, are 5 Foot and 10 Foot Rods, and a Chain of 50 Foot long; for Fields and Woods, a Chain, which from its Contriver is usually called *Gunter's Chain*, and is in Length 66 Foot or 4 Poles, consisting of 100 Links, each containing 7 Inches and $\frac{9}{10}$; and a Rod, called an *Offset-Staff*, whose Length is equal to $\frac{1}{18}$ Part of the Chain, that is 10 Links, or 6 Foot 7 Inches and $\frac{2}{10}$, tho' sometimes this Rod is 15 Links in Length, or 9 Foot 10 Inches and $\frac{8}{10}$; for Roads, the Wheel.

The Instruments used for taking the Positions of Lines are of two kinds.

With

With some we take the Position of a Line, by the Angle which that Line makes with the Meridian, using a Box and Needle; as with the *Theodolite*, the *Semi-Circle*, the *Circumferentor*, the *Plain-Table*, the *Perambulator*, the *Peraſtor*, &c. and this is usually called the *Bearing of the Line*.

With others we take the Position by the Angle that the Line makes with any other given in Position; as with the Limb of the *Theodolite*, the Limb of the *Semicircle*, the Frame of the *Plain-Table*, the *Bevel*, the *Chain*, or *Rods*.

All other Instruments either differ from these only in their Names, or else are contained in them.

But with some of these Instruments, very conveniently we take the Position in both ways, at one Observation; as with the *Theodolite*, the *Semi-circle*, or the *Plain Table*.

With some of these Instruments we take the Angle itself, as with the *Bevel*, or with the *Plain Table* cover'd with a Sheet of Paper; and with others, we express the relative Quantity of that Angle by Numbers. So when we use the Chain, we express the Angle by Sextants, Links, and Tenth Parts of a Link; when we use Rods, we express it by Sextants, and centesimal Parts of a Rod; and when we use other Instruments, we express the Angles by Degrees and Minutes.

We may also observe, that of *Theodolites* and *Semicircles* there are various Kinds; in some the Box and Needle is fix'd to the Plate, in others to the Index. And the working

working with each of these varies according to the Manner of their Numbering.

As for Roads, the Wheel, with its Indices, shewing the Distance, and its Box and Needle with Sights shewing its Bearing or Position in respect of the Meridian, is an Instrument speedy and sufficiently exact: provided we reject the Breadth of the Road, and only regard the Bearing and Length.

Lastly, Instruments for plotting, are a Scale decimally divided the whole Length, close to both the Edges; and at every tenth Division numbered 0, 1, 2, 3, 4, &c. denoting Chains; the Numbering ordered that we may count either from the Right to the Left, or from the Left to the Right; and a *Protractor* always to be divided, numbered, and fitted according to your Instrument; namely,

For all *Circumferentors* (either so distinctly, or used as such, *viz.* when contained in the *Theodolite*, *Semicircle*, or *Plain Table*) let the Numbers in the *Protractor* increase contrary to those in the Box; but when the Box and Needle takes the Bearing, as the *Peractor* or *Perambulator* doth, the Numbers of the *Protractor* must increase as those in the Box. And for the Limbs of all *Theodolites*, *Semicircles*, and *Plain Tables*, if the Circuit be made {according
{contrary } to the Numbers on the Limb, the Numbers of the *Protractor* most conveniently increase the {contrary
{same } way with the Numbers on the Limb of the Instrument, and this supposing the Eye in the Center.

SECT.



S E C T. III.

*To observe the Position of a Line by
any of the preceding Instruments.*

1. *By the Circumferentor.*

THE Box of the *Circumferentor* is divided into 360 Degrees, and numbered in 4 Quarters, from the North and South both to the East and West, by the Figures 10, 20, 30, 40, 50, 60, 70, 80, 90; but these Divisions are also numbered from the North towards the East or West, all round, till they end at the North again; by the Figures 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, and so on to 360. Of these two ways of numbering, the latter is properly the *Circumferentor*, and the former the traversing Quadrants or Quarters.

Now, if it be required to observe the Bearing of the Line AB (*Fig 12.*) the Instrument standing at A; The Flower-de-luce in the Box being towards you, direct the Sights
to

to B; and the South End of the Needle will point at 207 Degrees in the *Circumferentor*, and at S. W. 27, in the traversing Quadrants.

And if you were going round the Field, and so next to observe the Bearing of the Line BC; at B turn the Index about, the Flower-de-luce being towards you, till thro' the Sights you see the Hair cut C: then will the South End of the Needle point at 111, in the *Circumferentor*, (which is the Bearing always counted from the North, and in these Examples indeed Eastward) and at S. E. 69 in the traversing Quadrants, which is the Bearing always counted from the North or South towards the East or West. Here we may Note, that the Bearing taken with the *Circumferentor* may be any Number of Degrees not exceeding 360, but that with the traversing Quadrants never exceeds ninety Degrees.

When you suspect the Needle doth not play well; direct your Index to your Mark, and note the Degrees pointed at by the Needle in a waste Piece of Paper; then with a clean Knife, or a Key, or any other polished bit of Steel, which hath touched a Loadstone, move the Needle, by applying it to the Box, and examine, when it hath settled again, what Degree it then points at, your Index being still directed to the preceding Mark; and if the Degrees are the same, they may be entered into the Field-Book; but if not, the Cap and Pin must be cleansed with some brown Paper and a little Puttey,

Puttēy, and thereby freed of such Dust or Dampness as hath gotten to it ; if, after all, the Needle doth not play freely, screw in a new Pin, or use another Needle, or do both. These Necessaries every Surveyor ought to have in his Pocket while he is in the Field.

If you suspect any Error in the Bearing of any Line already taken, arising from the Needle's being acted on by some hidden Magnetick Power, or from your own Mistake in observing the Degrees pointed at ; the Doubt may be cleared, and the Error corrected at the next Station ; thus,

Having come to B (*Fig. 12.*) the Flower-de-luce being from you, look back to A, and then will the South End of the Needle point at 207 Degrees in the *Circumferentor* and at S. W. 27 Degrees in the traversing Quadrants ; just as it did at A.

Lastly, if you have no Reason to suspect the Needle, and it is most convenient to plot by it, the speediest way is to place the Instrument only at every other Angle, and there to take the Bearings of the two Lines constructing that Angle.

So, if you would observe the Bearings of the Lines of *Fig. 12.* first place the Instrument at B, and with the Flower-de-luce from you, direct the Sights back to A, so the South End of the Needle will point at 207 Degrees in the *Circumferentor*, and at S. W. 27 Degrees in the traversing Quadrants, which is the Bearing of A B ; then with the Flower-de-luce next you, direct the Sights
to

to C, so the South End of the Needle will point at 111 Degrees in the *Circumferentor*, and at S. E. 69 Degrees in the traversing Quadrants, which is the Bearing of BC.

Now place the Instrument at D, the Flower-de-luce being from you, direct the Sights back to C, so the South End of the Needle will point at 44 Deg. 30 Min. in the *Circumferentor*, and at N. E. 44 Deg. 30 Min. in the traversing Quadrants, which is the Bearing of CD; and directing the Sights to E, the Flower-de-luce being towards you, the South End of the Needle will point at 102 Degrees 15 Minutes in the *Circumferentor*, and at S. E. 47 Degrees 45 Minutes in the traversing Quadrants.

In like manner work at F, &c. always keeping the Flower-de-luce from you when you look backwards, and towards you when you look forwards; so will the South End of the Needle point at the Degrees of the Bearing in both Cases.

To protract any Line whose Bearing is taken by the Circumferentor.

FIRST, draw Lines parallel to one another quite thro' the designed Draught, at Distances not exceeding the Breadth of the Diametrical Part of your *Protractor*, as in Fig. 12. and mark them with N. and S. for North and South; then lay the Center of the *Protractor* on A the Point given, representing the Station A in the Field, and, by

Help of the Divisions continued beyond the Ends of the Diameter of the *Protractor*, lay the Diameter parallel to those North and South Lines, and if the *Protractor* be only a *Semicircle*, lay the Beginning of the Numbering Northwards, when the Degrees are fewer than 180, but Southwards when more: The *Protractor* being thus placed close to the Limb against 207, the Degrees of the Bearing, make a Mark, and to it draw the Line AB; and so will AB have a Bearing like to that, which you observed the Line AB to have in the Field. In like Manner you may lay down the Bearing of any other Line, as BC; if you observe to lay the Beginning of the Numbering Northwards, when the Degrees are less than 180, and Southwards when more: But if the *Protractor* be a whole Circle, there will be no Occasion for turning the Beginning of the Numbers.

And if you would lay down the Bearing of any Line AB from any assigned Point A, with the traversing Quadrants; after you have drawn North and South Lines as before, the North being upwards, write East on the right Hand Side of the Map, and West on the Left. Now lay the Center of the *Protractor* and Diameter as before taught; save that instead of observing the Number of the Degrees, you turn the Limb of the *Protractor* Eastward, when the Bearing is N. E. or S. E. and Westward, when it is N. W. or S. W.

The

The *Protractor* being thus placed, against S. W. 27. make a Mark, and to it draw the Line AB, and so will AB have a Bearing like to that which AB was observed to have in the Field. In like manner you may lay down the Bearing of any other Line.

2. *To observe with a Theodolite, both by the Limb, and by the Box and Needle.*

BEFORE you engage in a Survey, you ought to consider the numbering of your Instrument; thus, when the Eye is conceived plac'd in the Center, consider whether the Numbers increase from the Left to the Right; or from the Right to the Left; or, according to the Farmer's familiar Phrase, whether the Numbers increase with or against the Sun's Motion.

And then observe, that with a *Theodolite*, whose Box is fixed to the $\left\{ \begin{array}{l} \text{Plate} \\ \text{Index} \end{array} \right\}$ the Circuit is most conveniently made $\left\{ \begin{array}{l} \text{with} \\ \text{against} \end{array} \right\}$ the increasing of the Numbers; and the fix'd Sights shall always be directed to the $\left\{ \begin{array}{l} \text{next} \\ \text{last} \end{array} \right\}$ Station, and the Index to the $\left\{ \begin{array}{l} \text{last} \\ \text{next} \end{array} \right\}$: And then if you keep the Beginning of the Degrees towards you when you direct the fix'd Sights, and the Flower-de-luce towards you when you direct the
C Index;

Index ; the Degrees cut by the End of the Index which is next you, are the Degrees of the Angle ; and the Degrees pointed at in the Box by the South End of the Needle, give the Bearing of the next Length. And this Bearing will be, in all respects, the same with that taken with the *Circumferentor* ; provided that the Box be divided and numbered like that of the *Circumferentor*.

This double Observation is of great Use to the Surveyor ; for hereby he may either plot by the Angle or by the Bearing, or both, as he shall find most convenient ; and also, he may prove his Observation before he moves his Instrument. For, of the Numbers expressing the Bearing of the Lines forming any Angle, if the lesser be subtracted from the greater, and the Remainder be $\left\{ \begin{array}{l} \text{increased} \\ \text{diminished} \end{array} \right\}$ by 180 Degrees when $\left\{ \begin{array}{l} \text{less} \\ \text{greater} \end{array} \right\}$ than 180, the Result will give either the Angle itself, or its Supplement to 360 Degrees.

When we use a *Theodolite* with a Box fixed to the $\left\{ \begin{array}{l} \text{Plate} \\ \text{Index} \end{array} \right\}$ and the Numbers in the Box increase the $\left\{ \begin{array}{l} \text{same} \\ \text{contrary} \end{array} \right\}$ way with the Numbers on the Plate, as they generally do, or as I would chuse to have them ; then a *Protractor* being numbered contrary to the Numbers in the Box, will be fitted to lay down the Plan, either by the Angles taken by the Limb, or by

by the Bearing taken by the Needle, or by both together, in order to prove the Truth of each other: And then also may the Truth of the Angle or Bearing be proved, before the Instrument is moved from the Station by either of the two following Rules.

If to the present Bearing be added 180 Degrees, and from the Sum you subtract the last Bearing; then the Remainder will be the present Angle.

And if to the present Angle you add the last Bearing, and from the Sum subtract 180; then will the Remainder be the present Bearing.

But if the Degrees to be subtracted are more than those from which they are to be subtracted; the latter must be increased by 360, and then subtract.

And if the Remainder be more than 360, then abate 360, and the Result gives the Degrees required.

So, with a *Theodolite* that hath the Box fix'd to the Index, and the Numbers on the Plate, while the Eye is conceived placed in the Center, increase from the Left to the Right, but those in the Box the contrary way, and so most proper to work against the Sun: if you would take the Bearings of the Lines of *Fig. 12.* and if you would begin from any assigned Angle, suppose A; then your Instrument being planted at A, direct the Index to the next Station at B, and the South End of the Needle will point at 207 Degrees in the *Circumferentor*. And for the following Angles and Bearing, when the In-

Instrument is planted at $\left. \begin{matrix} B \\ C \\ D \\ E \\ F \\ G \end{matrix} \right\}$ direct the fix'd Sights to $\left. \begin{matrix} A \\ B \\ C \\ D \\ E \\ F \\ G \end{matrix} \right\}$

and there screw the Instrument fast, and then direct the Index to $\left. \begin{matrix} C \\ D \\ E \\ F \\ G \\ A \end{matrix} \right\}$

and the End of the Index next your Eye will cut on the Limb the Angles - - - - - $\left. \begin{matrix} 84. & 00 \\ 113. & 30 \\ 237. & 45 \\ 49. & 35 \\ 102. & 40 \\ 234. & 00 \end{matrix} \right\}$

and the South End of the Needle will, as in the *Circumferentor*, point at - - - - - $\left. \begin{matrix} 111. & 00 \\ 44. & 30 \\ 102. & 15 \\ 331. & 50 \\ 254. & 30 \\ 308. & 30 \end{matrix} \right\}$

And with a *Theodolite*, that hath the Box fixed to the Index, and the Numbers of the Plate contrary to those of the Box, while the Eye is conceived placed in the Center, increase from the Right to the Left, and so most proper to work according to the Sun's Motion; if you would take the Angles and the Bearings of the Lines of *Fig. 12.* and begin from any assign'd Angle, suppose A; then your Instrument being planted at A, direct the Index to the next Station G, and the South End of the Needle will point at 231° 30' in the *Circumferentor*. And for all the

the following Angles and Bearings, when the

Instrument is planted at $\left. \begin{matrix} G \\ F \\ E \\ D \\ C \\ B \end{matrix} \right\}$ direct the fixed Sights to $\left. \begin{matrix} A \\ G \\ F \\ E \\ D \\ C \end{matrix} \right\}$

and there screw the Instrument fast,
and then direct the Index to $\left. \begin{matrix} F \\ E \\ D \\ C \\ B \\ A \end{matrix} \right\}$

and the End of the Index next
the Eye will cut on the Limb
the Angle - - - - - $\left. \begin{matrix} 234. & 00 \\ 102. & 40 \\ 49. & 35 \\ 237. & 45 \\ 113. & 30 \\ 84. & 00 \end{matrix} \right\}$

and the South End of the
Needle as in the *Circumferentor*,
will point at the Bearing - $\left. \begin{matrix} 285. & 30 \\ 208. & 10 \\ 77. & 45 \\ 135. & 30 \\ 69. & 00 \\ 333. & 00 \end{matrix} \right\}$

But with a *Theodolite* that hath the Box fixed to the Plate, and the Numbers on the Plate as well as those in the Box (the Eye being placed in the Center) increase from the Right to the Left; and therefore most proper to work contrary to the Sun's Motion; if you would take the Angles and the Bearings of the Lines of *Fig. 12.* and begin at an assigned Angle A; then your Instrument being planted at A, direct the fixed Sights to B, and the South End of the Needle will point at 207° 00', as in the *Circumferentor*,

and as in the first Example. And for all the following Angles and Bearings, when the In-

strument is planted at $\left\{ \begin{matrix} B \\ C \\ D \\ E \\ F \\ G \end{matrix} \right\}$ direct the fixed Sights to $\left\{ \begin{matrix} C \\ D \\ E \\ F \\ G \\ A \end{matrix} \right\}$

then screw the Instrument fast, and direct the Index to - - - - $\left\{ \begin{matrix} A \\ B \\ C \\ D \\ E \\ F \end{matrix} \right\}$

so will the End of the Index next the Eye cut on the Limb, the Angle - - - - - $\left\{ \begin{matrix} 84. 00 \\ 113. 30 \\ 237. 45 \\ 49. 35 \\ 102. 40 \\ 234. 90 \end{matrix} \right\}$

and the South End of the Needle, as in the *Circumferentor*, will point at the Bearings - - - $\left\{ \begin{matrix} 111. 00 \\ 44. 30 \\ 102. 15 \\ 331. 50 \\ 254. 30 \\ 308. 30 \end{matrix} \right\}$

both as in the first Example.

Also with a *Theodolite*, that hath the Box fixed to the Plate, and the Numbers on the Plate, as well as those in the Box, the Eye placed in the Center ; increase from the Left to the Right, and therefore most proper to work according to the Sun's Motion ; if you would take the Angles and the Bearings of the Lines *Fig. 12.* and begin at an assigned Angle at A, direct the fixed Sights to G, and the South End of the Needle will point at

231° 30' as in the second Example. And for all the following Angles and Bearings when

the Instrument is planted at $\left. \begin{matrix} G \\ F \\ E \\ D \\ C \\ B \end{matrix} \right\}$ direct the fixed Sights to $\left. \begin{matrix} F \\ E \\ D \\ C \\ B \\ A \end{matrix} \right\}$

then screw the Instrument fast, and direct the Index to - - - - - $\left. \begin{matrix} A \\ G \\ F \\ E \\ D \\ C \end{matrix} \right\}$

and so will the End of the Index next the Eye cut on the Limb, the Angle - - - - - $\left. \begin{matrix} 234. & 00 \\ 182. & 40 \\ 49. & 35 \\ 237. & 45 \\ 113. & 30 \\ 84. & 00 \end{matrix} \right\}$

and the South End of the Needle, as in the *Circumferentor*, will point at the Bearings - - - $\left. \begin{matrix} 285. & 30 \\ 208. & 10 \\ 77. & 45 \\ 135. & 30 \\ 69. & 00 \\ 333. & 00 \end{matrix} \right\}$

both as in the second Example.

With either of these four Instruments, the Angles and the Bearings of the Lines are taken, at once setting the Index, as easily and expeditiously as the Angle itself only; which evidently appears from the Four preceding Examples. And the Truth of these Observations may be readily proved by either of the Rules already laid down.

For, the Instrument being planted at B, in the first and third Examples, if to 111°

00' the Bearing there taken, you add $180^{\circ} 00'$ and from the Sum $291^{\circ} 00'$, take the last Bearing $207^{\circ} 00'$, there will remain $84^{\circ} 00'$, which gives the Angle taken at B, exactly as there observed; and proves the Angle and these two Bearings to have been truly observed.

In like manner, the Instrument being planted at C, in the same Examples; if to the Bearing there taken, $44^{\circ} 30'$, you add $180^{\circ} 00'$, and from the Sum $224^{\circ} 30'$, you subtract $111^{\circ} 00'$, the Bearing taken at the last Station; the Remainder $113^{\circ} 30'$ gives the Angle at C exactly as it was there observed; which proves that the Angle, and also the last and present Bearings are truly observed.

Also the Instrument being planted at D; if to the Bearing there taken $102^{\circ} 15'$, you add $180^{\circ} 00'$, and from the Sum $282^{\circ} 15'$, take $44^{\circ} 30'$ the last Bearing; the Remainder $237^{\circ} 45'$ gives the Angle at D, as there observed.

But the Instrument being planted at E, if to the Bearing there taken, $331^{\circ} 50'$, you add $180^{\circ} 00'$, and from the Sum $511^{\circ} 50'$ you subtract $102^{\circ} 15'$, the last Bearing; the Remainder $409^{\circ} 35'$ lessen'd by 360° , because greater than 360 , gives $49^{\circ} 35'$, the Angle at E. And so of all the rest.

And in like manner may the Angles and Bearings be compared in the second and fourth Examples.

Or the Angles and Bearings may be compared by the second Rule thus: The Instru-
ment

ment being planted at B, if to $84^{\circ} 00'$, the present Angle, you add $207^{\circ} 00'$, the last Bearing, and from the Sum $291^{\circ} 00'$ you take $180^{\circ} 00'$, the Remainder $111^{\circ} 00'$, gives the present Bearing, as observed.

The Angles and Bearings being truly taken, it remains to shew how

To Plott, and therein to discover and correct an Error before it is communicated to the following Part of the Work.

HAVING provided yourself with a *Protractor*, whose Numbers increase contrary to those in the Box, draw all over your designed Draught parallel Lines, as in plotting Observations taken with the *Circumferentor*.

Then from some Point convenient to represent your first Station, as in the
 $\left. \begin{array}{l} \text{first and third} \\ \text{second and fourth} \end{array} \right\} \text{Examples from A, lay}$
 down by the Bearing $\left\{ \begin{array}{l} 207^{\circ} 00' \\ 231 - 30 \end{array} \right\}$ the first
 Line $\left\{ \begin{array}{l} AB \\ AG \end{array} \right\}$ as taught in plotting Observations taken with the *Circumferentor*.

Then on the Point $\left\{ \begin{array}{l} B \\ G \end{array} \right\}$ lay the Center of the *Protractor*, and its Diameter on the Line $\left\{ \begin{array}{l} AB \\ AG \end{array} \right\}$ produced both ways, if need require, so that the Beginning of the Degrees may be towards the last Station if the
 Angle

Angle be less than 180 Degrees, but the contrary way if greater; then at the Edge of the *Protractor* make a Mark against

$\left\{ \begin{array}{l} 84^{\circ} \text{ } 00' \\ 234 \text{ } 00 \end{array} \right\}$ the Degrees of the Angle $\left\{ \begin{array}{l} B \\ G \end{array} \right\}$

and draw the Line $\left\{ \begin{array}{l} BC \\ GF \end{array} \right\}$. Now turn the

Protractor about on its Center, till its Diameter be parallel to the Meridians, so that the Beginning of the Degrees be towards the North, when the Bearing is less than 180, but contrarily when more; and then if the

Line $\left\{ \begin{array}{l} BC \\ FG \end{array} \right\}$ cut the Bearing $\left\{ \begin{array}{l} 111^{\circ} \text{ } 00' \\ 285 \text{ } 30 \end{array} \right\}$

on the Edge of the *Protractor*, that Line is truly laid down: otherwise not.

In like manner, may any other Angle be examined, and if found erroneous, the Error may be corrected, before it is communicated to the following Part of the Work.

And we may observe, that, if the Plot be laid down by the Bearings of the Lines, those Bearings may be examined by measuring the Angles as soon as plotted.

Though this Method sufficiently recommends itself, both in respect of Dispatch as well as ACCURACY; I do not expect it will be practised by any but the Unprejudiced. For He, who hath surveyed much Land with a *Circumferentor* alone, or with a *Semicircle* or *Theodolite*, without a Needle, or with any other Instrument, that doth not afford a double Observation; He, I say, hath not provided a Check to his Frailty, and will scarce

scarce forsake his old Way, because he will not accuse himself.

There are two other ways to use these *Theodolites*, each equally exact with the former, but not so expeditious. One way is to take the Bearing with the traversing Quadrants; the other is to take the Bearing with the Degrees on the Limb. But the Angle is always taken as above.

If you would use the traversing Quadrants, then the observing, the plotting, and the Proof in plotting, are all as easily, speedily, and exactly done as by the first Method; but the Proof of the Observation in the Field, though equally true with the former, is neither so easily performed, nor so easily reduced to one single Rule. But the Person who is resolved to plot by the traversing Quadrants, had best take the Observation both by the *Quadrants* and by the *Circumferentor*; and then prove the Observation in the Field by the *Circumferentor*, and the Plotting by the traversing Quadrants.

Lastly, If you would take the Direction or Bearing by the Divisions on the Limb with a *Theodolite*, whose Box is fixed to the Plate, then (after you have taken the Angle, as before taught) turn the Instrument about till the North End of the Needle point at 360 Degrees in the Box, and screw it fast; now direct the Index to the next Station, and the End next you will give on the Limb the Direction in Degrees and Minutes, as in the former Examples.

But

But with a *Theodolite*, whose Box is fixed to the Index, if you would take the Direction by the Divisions on the Limb; then (after you have taken the Angle, as before taught) direct the fix'd Sights to the next Station, and screw the Instrument fast, and turn the Index about till the North End of the Needle point exactly at 360 Degrees in the Box; and then will the End of the Index nearest to the South End of the Needle cut on the Limb the Direction in Degrees and Minutes. But the *Protractor* to lay this Bearing down, must be numbred contrary to the Limb on the Instrument.

The great Advantage usually propos'd by this last Method, is, that the Degrees on the Limb are larger and more distinctly cut, and consequently more nearly estimated than those in the Box. But consider, that you can no better bring the Needle to point at any one Degree, than you can estimate its Position in any other Degree; and that since we use the Needle, all the Objections made in one Method are incident to the other; and then you may easily conclude, that the Advantage is only imaginary.

Besides, here we are oblig'd to take two Observations, either of which take up as much Time as the one Observation used in the former Method; which renders it not so fit for a Practitioner.

Of the Use of these *Theodolites*, I have one Thing more to advertise, *viz.* To measure and cast up the Content of one large single Wood or Common, where there are some scores of Angles

Angles to be taken; the safest Way is to cast, without plotting, by help of the Needle. And in this Case I would take the Directions both with the *Circumferentor* and the *traversing Quadrants*; and in the Field prove the Directions taken with the *Circumferentor* by the Angles taken by the Limb; and then, still in the Field, prove both Lengths and Directions, in calculating a Traverse, by help of a Traverse Table; and lastly, from this Traverse (at leisure) deduce the true Content.

But the Traverse Tables that are now extant, are but Specimens of those which are fit for Use; Instruments are not sufficiently exact, and Trigonometrical Operations too laborious, and therefore I must defer this way of Computation, till some Person who hath Leisure and Patience to serve the World, in calculating such a Table, is resolved to do it; If I can procure it, as indeed I have some Hopes thereof, it may be published, with its Uses in Practical Surveying and Navigation, in a Pocket Volume.

Of any one of the Four *Theodolites*, which have the Numbers in the Box contrary to those *Theodolites* before described, one or more Inconvenience will always arise, use which of the Three forementioned Methods you please.

It is true, the Angle taken by the Limb is perform'd as taught in the preceding Rules; but since it is not safe to work by the Limb only, if you use the *Circumferentor*, as taught in the first Rule, you must either subtract the Direction from 360 Degrees, and enter

the Remainder instead of the Direction pointed at by the Needle ; or else use two *Protractors*, which will be troublesome, and also apt to cause Mistakes by using the one for the other.

If you use the *traversing Quadrants* only, then indeed the Use is in all respects the same with the preceding ones ; but these, as I have already shewn, are not so expeditious as, nor more exact than, the Method first laid down.

If you will take the Direction by the Limb, and still make one *Protractor* plot both Observations, you must direct your Instrument twice, whereas by the first Method laid down, it might be done at once.

Lastly, Of *Theodolites* those are best which have Telescopes with plain Sight on them, and so contrived that the Surveyor may at any time adjust any small Accident, without coming to a Workman, and that both of them may be elevated or depressed at least ten Degrees ; one of these Telescopes instead of the fix'd Sight, the other instead of the moveable ones, and as long a Needle as will play well, with other the like Conveniences, sufficiently known to a skilful Instrument-maker.



3. *To Observe with a Semicircle that hath a Box and Needle.*

A Semicircle is just half the *Theodolite*, and admits of just as many Varieties; it is numbred on the Limb to 180 Degrees, and in an Arch concentrick to this is numbred under 10, 20, 30, &c. with the Numbers 190, 200, 210, &c. to 360. Its Use, in all respects (both to the Plate and Box) is the same with the *Theodolite*; save in this, that when the End of the Index next the Eye, falls off the Plate, the Degrees cut on the Limb are to be taken from the further Part of the Index from the Degrees of the inner Circle, and will be always more than 180 Degrees.

There are some other Manners of numbering and dividing (and perhaps without a Box and Needle) used in these Instruments; but they are not worth Notice.

4. *Of the Peractor.*

THE Peractor is the same with part of that *Theodolite*, whose Box is fix'd to the Plate; and the Directions given for the *Theodolite* in Page 27 and 28, will serve for this.

5. *Of*



Of the Plain Table.

THE Divisions on the Limb of the *Plain Table*, with its Box and Needle, being like those of the *Theodolite*, or *Modern Circumferentor* ; if the 360 Degrees of the Limb be upwards, and the Box and Needle screwed to the Side of the Table ; it performs, in all respects, the Use of the *Theodolite*, whose Box is fix'd to the Plate. For lay the Edge of the Index on the Division numbered 360, and to that numbered 180 ; and turn the whole Instrument about, till through the Sights you see the next Station (the 360 being towards you, as taught in the *Theodolite*) and there screw it fast ; then turn the Index about upon the Centre, till you see your last Station, and so will the End of the Index next you cut the Degrees of the Angle, and the South End of the Needle will give the Direction or Bearing.

But if the Box be screwed to the Index, it in like manner becomes a *Theodolite*, with a Box fix'd to the Index.

If the Box and Needle be screwed to the Staff, it is a *Circumferentor*.

If the Box be screwed to the Table, and that Side of the Frame be upwards, which is divided into four Nineties, it is the *Pereambulator*.

If that Side of the Frame is upwards, which hath only the 180 Degrees of the Semicircle numbred on it, then it is a Semicircle, either

either with the Box to the Plate or not, according as the Box is fix'd to the Table or the Index.

And what hath been already said of these Instruments may serve for Directions, to use the plain Table these several Ways, and need not be again repeated here.

And hence it seems that the plain Table might properly be called *Panorganon*, in respect of Land Surveying.

Indeed, if instead of the small Holes for Centers to be used with a Protracting Pin by the Fiducial Edge of the Index, there were Conick Holes through the Table; and also a Hole, being the next adjoining great Segment of the same Cone made in the Index to screw it to the Center by a Conical Pin at the End of it; and the Fiducial Edge of the extreme Parts was filed away, so that when continued, they would pass thro' this Central Pin; and if the Divisions on the Frame be cut as accurately as on the Limb of a *Theodolite*; and if also the Wood would neither shrink nor swell any more than Brass; and a Telescope mounted on the Sights; and the Back-side of the Index brought also to a Fiducial Edge; then I should think it a very compleat Instrument.

It remains to shew, how to take Angles when we use the plain Table covered with a Sheet of Paper; but this hath been sufficiently handled by Mr. *Leybourn*, and almost all the common Writers on Surveying; therefore I shall content myself with laying down a Method to correct an Error committed be-

fore it is communicated to the following Parts of the Work. Though I do not any ways doubt but the Reader may, by what follows, learn the Use of this plain Instrument.

Suppose you were to draw the Plan of the Field ALMNQR; (*Fig. 13.*) draw on the Table a Line to represent AL in the Field, and by your Scale lay down on the Plan the Distance you found AL in the Field to be, when you measured it with a Chain. Then planting your Table at L, lay the Index on AL, and turn the whole Instrument about till you see A, and then screw it fast, then turn the Index about on L, till through the Sights you see M, and draw LM; and by your Scale give it on the Table the same Length you found it to have in the Field, by measuring with your Chain.

Now in order to examine the Length of LM, and also its Position in respect of AL; plant your Instrument at M, lay the Index on LM, and by turning the Instrument, direct the Sights to L, and there screw it fast; then direct the Index turn'd about on M, towards A in the Field, and if the Edge doth not cut the Point A in the Table, the Line LM is false, either in Position or Length, and therefore must be examined and corrected before you proceed.

The Line LM being truly laid down, plant the Instrument at M, and lay the Index on LM, and direct the Sights to L, by turning round the whole Instrument, and then
screw

screw the Instrument fast : Now turn the Index about on M, till through the Sights you see the Hair cut N, and by the Edge of the Index draw a strait Line ; and by your Scale, from M lay the Length N M equal to what you measur'd it in the Field.

But to prove whether the Line NM is truly laid down both in Position and Length ; having planted the Instrument at N, and directed the Index on NM to M, and there screwed the Instrument fast ; from N direct the Index to either of the Marks L or A in the Field ; and if the Index then doth not accordingly cut L or A on the Table, the Line MN is false, and must be corrected before you proceed.

And in like manner through the whole Survey, you may proceed to lay down every Line, and examine it before you leave it, provided that you leave your Marks all standing at every Station, by laying the Index on the last Line, and turning the Instrument about till thro' the Sights you see the Hair cut the last Mark ; and then screwing the Instrument fast ; if you turn the Index about on the Point representing the Station where the Instrument stands, till you see any one of the Marks passed by, except the last of all ; and if the Edge of the Index doth not cut on the Table, the Representative of that Point, the last Line is not truly laid down.

But when you are at any Mark, suppose N, if you cannot see any other Mark but M, set up some Mark *a*, from whence you

may see some of the preceding Marks, suppose L, as well as M and N; and from this Point *a* examine the Truth of the Position of the Line MN.

Or thus; You may set up a Mark *a*, any where in the Field, from whence all, or several of the Angles may be seen; then the Instrument being at A, and the Index on AL, screw the Instrument fast; and turn the Instrument on A, till you see *a*, and draw A *a*.

The Instrument being at L, the Index on LA, and the Index directed to A; let the Instrument be screwed fast; turn the Index about on L, till thro' the Sights you see *a*, draw by the Edge of the Index L *a*; and so will the Point *a* be determined.

Then the Instrument being at M, the Index on LM, and the Sights directed to L, and the Instrument screwed fast, turn the Index about on M, till thro' the Sights you see the Mark *a* in the Field: Then if the Edge of the Index doth not cut *a* in the Table; the Line LM is false either in Position or Length.

In like manner the Table being at N, the Index on NM, and the Sights directed to M, and the Instrument screwed fast, turn the Index about on N, and direct the Sights to the Mark *a*; and if the Edge of the Index doth not cut *a*, on the Table; then MN is false either in Position or Length.

Lastly, instead of a Mark set up as *a*, you may use any remarkable Tree, Steeple, &c. not at too great a Distance from you, whether

whether it be in the Land you are then Surveying, or not.

And when the Mark you have last used is at too great a Distance from you, or lies almost in the same strait Line with that which you are about to lay down; then use some other Mark in its stead.

6. *Of working with the CHAIN.*

FIRST, provide a Staff just 6 Foot 7 Inches and two Tenths long, which divide into 10 equal Parts; and so will the whole be the Length of 10 Links, and each Part the Length of one, and 10 times the Length of this Staff the Length of the whole Chain.

With this Staff examine the Length of the Chain, and also of every 10 Links; stretching it on level Ground, to such a Degree as you design to stretch it, when you measure with it.

Before you measure with it, provide 9 Arrows or small Sticks, each about Two Foot long, and two strait Staves about 5 Foot long each: These Arrows may be made of *Ground Ash*, a tough Wood and not apt to break; let them be shod with Iron Ferrils at one End, and have Pieces of red Rag tied at the other End, whereby they will be very readily distinguish'd and discovered when set down in long Grass or Corn.

When you are about to measure with it, let him that leads the Chain take the 9 Ar-

rows and one of the Staves ; and he that follows it the other Staff.

Then the Follower standing at the Station, let him direct the Leader to place his 5 Foot Staff at the Chain's End in the same right Line with the Stations ; and then let the Leader take up the Staff, and in its Place sticking down one of the Arrows, go on.

Now the Follower being come to the Arrow, let him direct the Leader to place his Staff as before.

And then let the Leader, standing at his Staff, look back towards the last Station, and he will see the Staves and the Station in one right Line, if they have directed right. But if they are not in one right Line, the Leader must direct the Follower to place his Staff at the Chain's End, in the same right Line with the Station, and the Leader's Staff.

And so, let each direct the other, till the two Staves and the two Stations are in one right Line ; and then must the Leader put down an Arrow in the Place of his Staff, and go on : And the Follower take up the Arrow where he last stood, and go after him.

And let him thus proceed till they have measured to the Station, or till the Leader is nearer the Station than one Chain's Length ; and then will the Number of the whole Chains measured, be expressed by the Number of the Arrows pricked down, which suppose 8,

Now

Now let the Leader go on to the Station, and there hold the End of the Chain, and let the Follower stretch the Chain as usual, and then see how many Links are contained between the last Arrow and the Station ; which may be readily counted by help of different Bits of Brass, or Curtain Rings, or other Marks fixed at the End of every tenth Link, which Links suppose to be 47.

Lastly, Enter in your Field Book the Chains and Links without any Distinction between them, and they will be 847 ; which imply either 847 Links, or 8 Chains 47 Links.

But here we are to observe that the Links must always possess two Places ; as 8 Chains and 4 Links must be written 804 ; that is 8 Chains and 4 Links, 804 Links ; and 8 Chains without any Links, must be written 800, implying 8 Chains, or 800 Links.

It is necessary that the Surveyor should enquire of his Assistants at the End of every measur'd Length, how many Arrows each hath ; and if the Sum of the Arrows are not nine, it is evident they have dropt or left behind, those that are wanting ; and consequently the last Length measured is doubtful, and must be re-measured before you proceed.

When you are come to the Station, if it be convenient to continue the Length, let the Follower stand at the last Arrow, and let the Leader go on with the Chain, and so place his Staff, that it and the two Stations are in one right Line ; then in the Place

of the Staff put down an Arrow, and go on ; always directing himself to place his Staff, and consequently his Arrow, by the two Stations.

When you have continued your Length, till you have nearly lost Sight of the farthest Station, set up another Station-staff in the place of the last Arrow, and go on to continue by the two nearest Stations.

But withal take this Caution, That it is not safe to continue Lengths very long, when the Stations are near one another.

Lastly, When your Length is very great, having measured nine Chains, let the Leader go on and set his Staff down at the Tenth ; now let the Follower put his Staff in the Place of the Leader's, and give the Leader the nine Arrows, and then go on. But observe to enter in your Field-Book these ten Chains, and never trust to your Memory. And if your Length consists of ten Chains more, work as before, and enter 20 Chains, and so on.

For a Shift, the Surveyor may perform many Works with the Chain ; but this at best is both laborious and tedious, the only Instruments for Surveying all manner of Lands both great and small in all Cases, being the *Theodolites* before-mentioned ; yet lest there should sometimes be an absolute Necessity for taking the Position of a Line by the Chain when other Instruments are wanting, we have here added the Method of taking an Angle therewith.

In

In order to do this, provide three round Sticks, very strait, and about four or five Foot long. And if you were to take any Angle as $\angle DBC$ (*Fig. 2*) first place one Stick upright in B , and there hold one End of the Chain, and let your Assistant carry the other End and another Stick towards C , and direct him to move Side-ways, till the Stick held upright at E , be exactly in the right Line BC , where let him leave it.

Then let him take the End of the Chain and move towards D , and, as before, direct him to plant the third Stick upright in the Line BD at F .

Then measure the Distance EF in Links and decimal Parts of a Link, if less than one Chain, and enter them in the Field Book : So if the Distance EF were 94 Links and 7 Tenths of a Link, they might be enter'd thus, 0^s. 947^{Parts}. denoting 0 Sextants, 947 Parts.

In this Work great Care ought to be taken, that the Sticks be as strait as a Workman can shoot them with a long Plane ; and that they are planted either exactly perpendicular, or at least so that the Sticks planted at B and E , and the Mark C may be exactly in the same Plane, and also the Sticks B and F , and the Mark D in another Plane.

But because it is very difficult to erect a Stick exactly perpendicular, it will be easier to perform the latter; thus, plant the Stick as nearly perpendicular as you can ; then move your self backwards towards G , the farther the better, till your Eye, the Stick

at B, and the Mark at C, are all in one strait Line, there stand and direct your Assistant to plant his Stick, so that the Stick at B exactly cover it from the Top to the Bottom.

But if it so happen, that you cannot move backwards at all towards G; then having planted the Stick at B, as upright as you can, let your second Assistant move forwards towards C, and let him there direct your first Assistant to plant the Stick at E, so that it exactly cover the Stick at B, while you direct him to place it in a right Line with the Stick B and the Mark at C; and the like Caution must be used in planting the Stick F. Nevertheless it will often happen so that the Mark at D may be a little shifted, and in this Case, Time and Trouble may be a little lessened; for having planted the Stick at F nearly in a true Position, move forwards towards D, and direct your Assistant to incline the Stick at F, so that it exactly cover the Stick at B, then returning to B, direct your Assistant at D to place the Mark in a right Line with the Sticks B and F.

But, secondly, if the Line EF be longer than the Chain (as in *Fig. B*) lay out a Sextant; thus while the Chain was laid from B to E, set down an Arrow at H 50 Links; then let your Assistants hold the Chain's Ends at H and B, while you with the Middle in your Hand, laying both Halves strait; set down an Arrow at I, and so constitute the Equilateral Triangle HBI; and therefore have thereby laid out the Angle HBI a Sextant. Now the Chain's End still held at B,

B, stretch it through the Point I to K, where also set down an Arrow; lastly, measure KF in Links and decimal Parts of Links, which suppose to be 76 Links and 4 Tenths; and then shall be entered in the Field Book 1^s 764 implying one Sextant and 764 Parts.

In like manner, if the Angle were more than two Sextants (as in *Fig. C*) then having laid off the Sextant HBI, let your Assistants hold the Ends of the Chain at B and I, while you with the Middle of the Chain in your Hand set down an Arrow at L, constituting the Sextant IBL; and then as before, the Chain being still held at B, lay it through L, and at the other End M, set down an Arrow; lastly, measure MO, which suppose to be 43 Links and 5 Tenths, and then enter in the Field Book 2^s 435, that is, 2 Sextants and 435 Parts.

If you would continue a strait Line, signify it by entering in the Book 3^s 000; that is, 3 Sextants.

If an Angle be external, and so contain more than three Sextants (as in *Fig. D*) let one Assistant hold one End of the Chain at B, and let the other Assistant stand with the other End of the Chain at E, and there hold a Stick, so that E, B and C, are in the same Plane as before taught, and also plant a Stick at F, so that the Sticks B and F, and the Mark D be also in the same Plane. Then measure the Angle EBF as already taught, and to it add three Sextants, and so will the Sum be the Measure of the external Angle CBD. So if the Angle GBD be 0^s 947, then

then will the external Angle CBD be $3^s\ 947$. But if the Angle GBD be $1^s\ 764$, then the external Angle CBD will be $4^s\ 764$. And if the Angle GBD be $2^s\ 435$, then the external Angle CBD will be $5^s\ 435$.

Now to plot any of these Angles thus taken (suppose that in *Fig. A*) chuse some Line divided into 1000 equal Parts, and with this Line describe an Arch ER , and lay thereon from E to F 947 equal Parts and draw BD .

And if you would plot the Angle taken in *Fig. B*, from B with the Length of the divided Line, describe an Arch EF , and lay thereon the Length of the divided Line from E to F , and afterwards 764 Parts from K to F , draw the Line BFD , and you will construct the Angle required.

Again, if you would plot the Angle of *Fig. C*, then as before, with the Length of the divided Line, describe the Arch EO , and thereon lay EP , PM , each equal to the Radius; and afterwards lay 435 equal Parts from M to O , draw BO ; and you have the Angle required.

Also if you would protract an Angle greater than three Sextants (as the external Angle CBD in *Fig. D*) first continue the Line CB , then from the Angle subtract three Sextants and make the Angle GBD equal to the Remainder.

Angles about Gardens or Buildings may be taken with Rods of 5 and 10 Foot, and laid down in all respects as with the Chain, but are no ways fitting for large Plans.

If

Fig: A

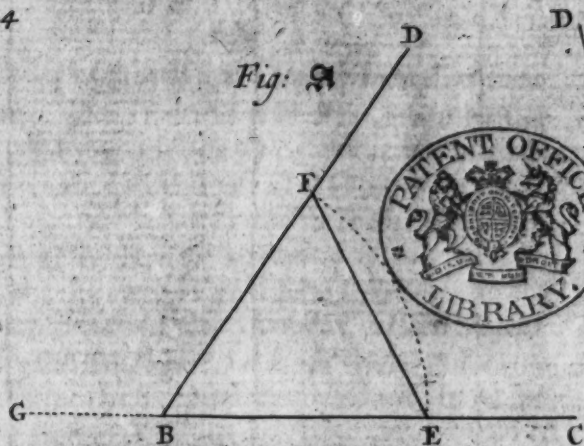


Fig: B

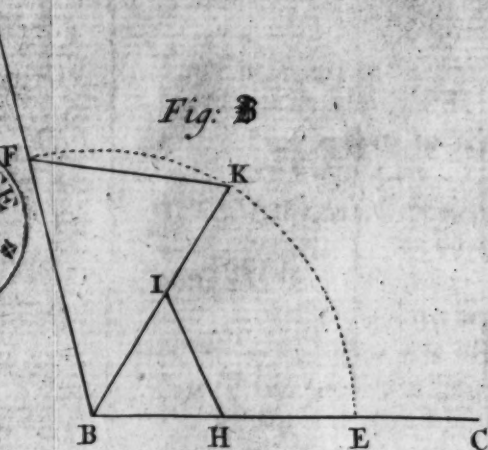


Fig: C

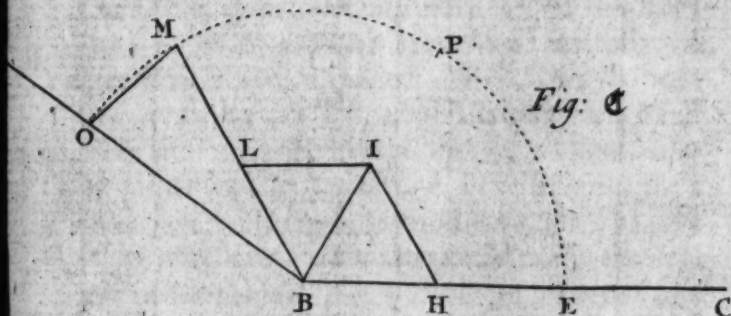
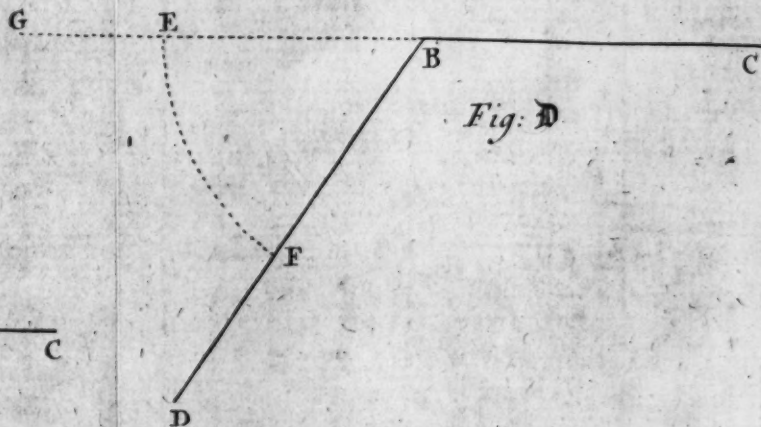


Fig: D



If the Surveyor have only a Chain, and hath drawn his Plan, and would draw thereon a Meridian Line; he may do it thus; Exactly at Twelve a Clock, mark the Shadow of some upright Object, as the Corner of a House, or some strait Tree, or your Staff set upright; then plot this Line on your Plan, and it is a Meridian Line.

Or thus; In a Night when the *Pole-Star* is to be seen, place your self so, that your Eye, the *Pole-Star*, and some upright Object as the Corner of a House or strait Tree, be in one strait Line; then plot the Line from your Feet to the upright Object, and it will be a Meridian Line.

Indeed the *Pole-Star* moves round the real Pole; but at so small a Distance from it, that in this Case the Variation may be rejected.

However, you may observe that the *Pole-Star* is full North about the 20th Day of

{ March and September at 12, April and October at 2, May and November at 4, June and December at 6, July and January at 8, August and February at 10 }	
--	--

a Clock either Morning or Evening; always increasing nearly 2 Hours for every Month.

Therefore if the Observation is made about these Times, the Variation will be very inconsiderable.

Also observe, That 5, 6, or 7 Hours before or after these Times, if the Pointers are
to

to { Eastward } of the Pole ; then the Variation by the Star is about 3 Degrees and a Half { Westward } ; and this Variation is the greatest.

Note, the Pointers are the two hinder Wheels of *Charles's Wain*, which are observed to be always in a direct Line with the *Pole-Star*.



SECT.



*To Cast up the CONTENTS of
LAND, with the Method of
reducing Irregular Curves to
Strait Lines.*



THE Contents of any Field may be readily cast up thus : Take every Base and every Perpendicular of every Triangle, and every Diagonal of every *Trapezia*, in Links, esteeming every Chain 100 ; in every *Trapezium*, multiply the Sum of the Perpendiculars by the Diagonal ; and in every single Triangle, the Base by the Perpendicular ; then add the several Products together : Then from the Right Hand make a Dash between the fourth and fifth Places, and another between the fifth and sixth ; then halve the Figures to the Left Hand of the Dashes, and so will this half be Acres. If an Unite remain, that Unite is an half Acre or two Roods ; and if the Figure between the Dashes be five or more, take five from it and account it another

ther Rood : *Lastly*, multiply the remaining Figure 0 between the Dashes by 8, and to the Product add the Tens to be carried from the Fourth Figure, and you have the Perches. If any Person is so curious, as to esteem the Decimal Parts of the Perches, they will be the Product made by multiplying the Figures to the Right-hand of the Dash by 8. So in Figure 14 the Operation will be thus.

$$\begin{array}{r}
 313 = AC \quad 214 = KL \quad FG = 418 \\
 612 = DE \quad 396 = HI \quad AH = 900 \\
 \hline
 925 \quad 610 \quad 376200 \\
 725 = BF \quad 500 = FM \\
 \hline
 4625 \quad 305000 \\
 1850 \\
 6475 \\
 \hline
 670625 \\
 \hline
 670625 \quad 670625 \\
 305000 \\
 376200 \\
 \hline
 13|5|1825 \\
 A. R. P.
 \end{array}$$

Answer, 6 : 3 : 1

Here half 13 gives 6 the Acres, and one remaining is 2 Roods ; then the 5 between the Dashes gives another Rood ; and so the whole is 6 Acres and three Roods ; and because there is but one Ten to be carried from the fourth Place, and that after the 5 is taken out of the fifth, there remains nothing, there is but one Perch.

In

In like manner if the whole Sum of all the

		A. R. P.
Products	$\left\{ \begin{array}{r l} 17 & 45364 \\ 11 & 92765 \\ 10 & 54321 \\ 8 & 43764 \end{array} \right\}$	the Con- tent is
be		$\left\{ \begin{array}{l} 8 . 2 . 36 \\ 5 . 3 . 34 \\ 5 . 1 . 03 \\ 4 . 0 . 35 \end{array} \right\}$

So if the Sum of the Products be 417|6354, the Content is 20 . 3 . 21|0832. But this Method must be only used when the Figure is reduced to Triangles and Trapezias.

It may not be improper, to add in this Place, the Manner of casting up such Fields as consist of many small Breaks in the Hedges ; without reducing them to a Multitude of Triangles ; *e. g.*

Let *Fig. 17.* be such a Field, produce NM, some one of the longest Sides ; then lay the Edge of a strait Ruler from M, one of the Angles at the End of NM, to G the next but one ; holding the Ruler thus fast, take with a Pair of Compasses the Distance from L to the Edge of the Ruler, and with this Distance let one Point of the Compasses move gently close to the Ruler, while the other Point traces out a Line parallel to it, and crosses NM in Q. Now draw GQ, and it will reduce that Side of the Figure, which was bounded by the two Lines ML LG, to another bounded by GQ, one single Line only.

In like Manner QG being produced, and a Ruler laid from G to E, carry the Distance of F from the Ruler parallel to it, till you cross MG in K. Secondly, Lay a Ruler

E from

from K to the next Point D, and carry the Distance of E, the last Point from the Ruler parallel to it, till you cross MG in H. Thirdly, Lay a Ruler from H to the next Point C, and carry the Distance of D, the last Point from it, parallel, till you cross MG in I. Lastly, Draw IC, and the Side GC which consisted of the four Lines GF, FE, ED, DC, will be reduced to the Side IC, consisting of one Line only. And in like manner we might proceed if the Lines were never so many.

And thus laying a Ruler from C to P, draw PO; and in like manner AQ. So will the ten-sided Figure be reduced to a four-sided one, and so may be cast up by one Multiplication only. The Practice of this will be render'd vastly easy by help of a parallel Ruler.

Provide a Plate of thin Brass in form of an Arch of a Circle; near whose Ends let there be drilled small Holes, through which string it with a very fine Hair. Being thus provided; when a Hedge as GC bends in and out in several Places, and those Bends contain very small Spaces, lay the Hair over it length-wise, so that the Quantities cut off from the Figure thereby may be equal to those added to it; and with your Protracting Pin near the Ends of the Hair make two Marks, through which draw a strait Line, and so will this irregular Side be reduced to a regular one. And here we may observe that in very small Bends, by the Eye, we judge better than we can by the Compasses.

Lastly,

Lastly, if Hedges consist of large Curvatures (as in *Fig. 18, 19.*) chuse out such Points, and so many of them, that right Lines drawn from Point to Point, may vary the Quantity by such Quantities only as may be rejected. And herein your Hair will be a ready Assistance.

S E C T. V.

Of the Laying out or Dividing of

L A N D.



E 2

S E C T.



S E C T V.

*Of the Laying out or Dividing of
L A N D.*

WHEN any Number of Acres, Roods and Perches are to be laid out, it is convenient to reduce them to square Links, which may be done thus:

If the Roods are $\left\{ \begin{smallmatrix} 1 \\ 2 \\ 3 \end{smallmatrix} \right\}$ add $\left\{ \begin{smallmatrix} 40 \\ 80 \\ 120 \end{smallmatrix} \right\}$ to the Per-

ches, and to the Sum annex 4 Cyphers. Divide this last by 16, and write the Quotient Figures, if they be 5, after the Acres.

But when the Quotient Figures are but $\left\{ \begin{smallmatrix} 4 \\ 3 \end{smallmatrix} \right\}$ write $\left\{ \begin{smallmatrix} \text{one Cypher} \\ \text{two Cyphers} \end{smallmatrix} \right\}$ after the Acres, and then the Quotient Figures; and so will you have the square Links required.

Ex. I.

A. R. P.

Ex. I. Reduce 7 2 24 to square Links.

24

80

16)1040000(65000

80000

Answer 765000

A. R. P.

Ex. II. Reduce 7 0 11 to square Links.

16)110000(6875

146

120

80

Answer 706875

A. R. P.

Ex. III. Reduce 7 0 01 to square Links.

16)10000(625

40

80

Answer 700625

The Problems of laying out Lands, as met within Practice, are in Number 3.

For, either the Partition Line is required to be parallel to some other Line assigned,

E 3

or

or to pass through some Point assigned in the Fence, or to pass through some Point assigned within the Land.

In the Solution of each of these, I chuse an Arithmetical Approximation rather than a Geometrical Construction; for Reasons sufficiently known to those who have practised.

P R O B. I.

Let it be required to cut off towards AB, Fig. 14, 8 Acres, 3 Rods, 18 Perches, by a Line drawn parallel to AB.

FIRST draw parallel to AB a Line CD by guess, and then cast up the Content of the Figure CDHG, which suppose to be 772575 square Links, which is less than A. R. P. 8 3 18, or 886250 square Links, by 113675 square Links, which shews, that the Partition Line is more towards K.

Now divide the Excess 113675, by 965, the Length of CD in Links, and at the Distance of 118 Links the Quotient, draw EF parallel to CD, and it will be sufficiently near the Partition Line required.

But if by Curiosity you are led to correct the Variation, you may conceive CD to be a Line given in Position, and 113675 square Links, to be the Quantity to be cut off, and EF the Line drawn by guess.

But if the Line CD had cut off the Quantity CDHG greater than that required, then the Partition Line had been more towards GH, whose Distance from CD would be found as before, by dividing the Difference by the Length CD.

P R O B. II.

To cut off $\overset{\text{A.}}{5} \overset{\text{R.}}{0} \overset{\text{P.}}{35}$ towards L, Fig. 15. by a Line drawn from the Point V.

Reducer the given Quantity $\overset{\text{A.}}{5} \overset{\text{R.}}{0} \overset{\text{P.}}{35}$ to square Links, and they will be 521875. Then draw LV, forming the Triangle VLW, which being cast up amounts to 30800 square Links, which is too little.

To the next Angle draw VM, forming the Triangle VLM, which being cast up will be found to amount to 297632 square Links, which added to the Triangle VLW, you have 328432 square Links, the Content of the Trapezium VWLM, which is still too little.

To the next Angle draw VP forming another Triangle, whose Content 403850 square Links added to 328432, the Content of the preceding Figure, gives 732282 square Links, which is more than the required Quantity by 210407 square Links; therefore the Partition Line passes between P and M. Divide the Excess by 497, half the Length

of V O the Perpendicular in Links, and lay
423 the Quotient from P to N, and so shall
V N be the true Line of Partition.

P R O B. III.

A. R. P.

To cut off 7 3 13 towards B from a
Line passing by the Point A. See Fig. 16.

IT may be thus performed: Consider
through which two Sides the Partition Line
will pass. Reduce the Figure to a *Trapezium*,
still retaining those Sides, as taught in Page
49: Which divide by a Line through the
assigned Point A.

But, because this Method is tedious, and
depends on the Concourse of many Lines,
and though we should use Numbers, we
should little mend the Matter, and indeed
is often impossible to be perform'd by one
single Line, it may not be amiss to shew
how to do it by two Lines.

From A to any two Angles H and B,
draw the Lines A H, A B, forming the
Triangle A H B, which being cast up,
amounts to 338000 square Links less than
the Quantity required.

To the next Angle C draw A C forming
the Triangle A B C, which being cast up,
amounts to 322500 square Links, which
added to the Triangle A H B, gives 660500
square Links, which are still less than the
Quantity required.

To

To the next Angle F draw AF, forming the Triangle ACF, whose Content 280800 square Links added to the preceding Triangles AHB ABC gives 941300, which exceeds the Quantity required by 158175 square Links; now divide this Excess 158175 by 292, half the Length of the Perpendicular EA, and lay the Quotient 541 from F to D, and draw AD, and so will the Lines HA, AD be the Partition required.



SECT.

To the next Angle F draw A F, forming the Triangle A C F, whose Content is 28000



SECT. VI.

The Use of the Theodolite exemplified in Surveying several Parcels of Land lying together, with the Form of a Field-Book.



AFTER a general Description of Instruments and their Uses, some practical Examples are necessary to illustrate and explain the particular Varieties which often occur.

The following Example I have handled in the same Method which I myself practise.

The Instrument which I use is a *Theodolite* numbered on the Limb from the Left to the Right, and in the Box (which is fixed to the Index) the ~~same~~ ^{contrary} Way; the Eye being supposed in the Center.

The *Chain*, the *Off-set-Staff*, the *Arrows*, &c. are as describ'd in the third Section.

The Field Book I divide into three Columns. The middlemost contains the several Lengths taken by the Chain. The outer-
↓ most

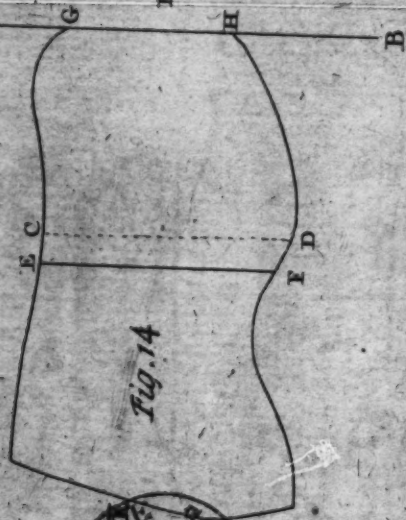


Fig. 14

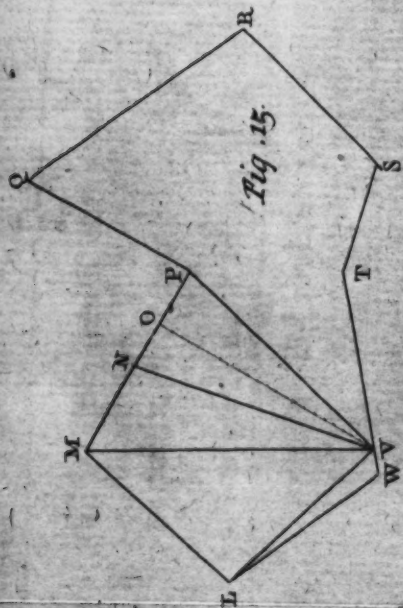


Fig. 15

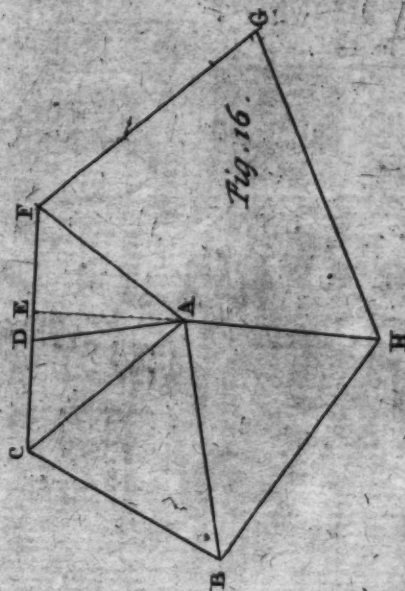


Fig. 16

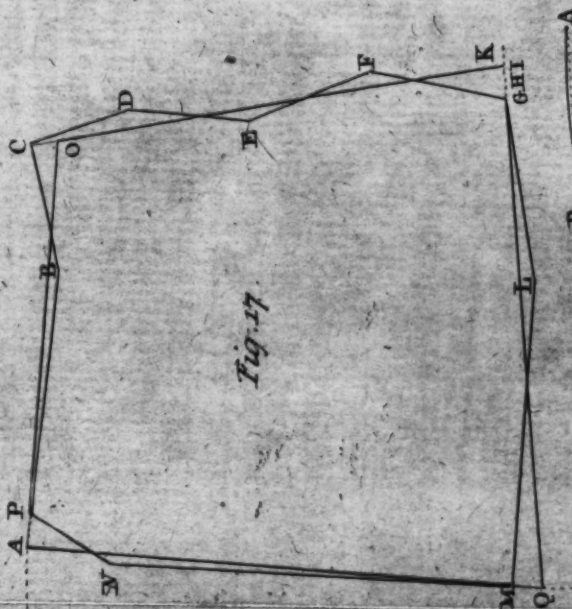


Fig. 17

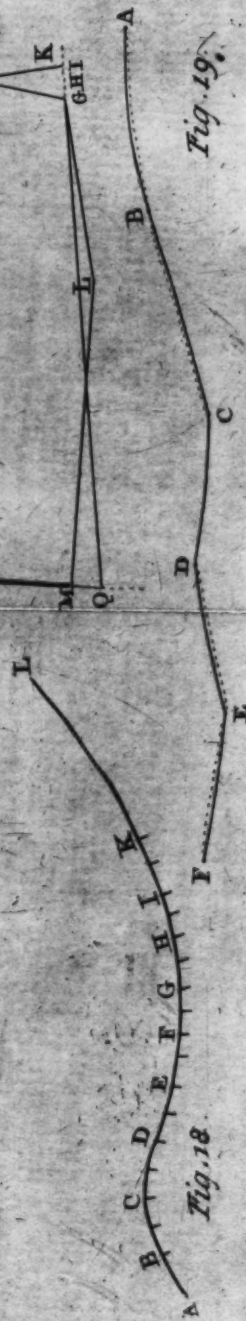


Fig. 18

Fig. 19

most Columns contain the several Off-sets, and the Description of the most remarkable Objects, which are to be met with in the Survey.

By the Mark $\odot$ I denote a Station; by $\angle$ I denote an inside Angle; and by ∇ an outside Angle; by (B) I denote a Bearing, by *Int.* I denote cutting a Hedge by the Chain; by *ag.* I denote some remarkable Object on the farther Side of the Hedge. These Symbols I have used instead of Words, because they constantly fall in the Way; but other Objects which are more rarely met with, I express by Words.

Being thus provided, in the first Page of the Field-Book, near the Top, I enter the Title of my Survey: Then having fixed my Instrument in some convenient Place, as *A* to begin at, I enter in the middle Column $\odot$ 1. denoting the first Station.

Here may be observed, that I always chuse to work in a Lane, as often as Opportunity presents.

My Instrument being planted at *A*, I send a Station-Staff forwards in the Lane as far as I can see distinctly, the farther the better, suppose to (B) and when I work in the Land, I send a Station-Staff to the next eminent Bend in the Hedge, or even to the farther End of it; if the Line from the Instrument to the Staff be not at too great a Distance from the Hedge, so as to cause Off-sets greater than a Chain, or a Chain and a half, or thereabouts. For Off-sets taken too great, produce some Uncertainties.

First

First

First then, I observe the Bearing of the Line AB, thus, the Flower-de-luce in the Box being towards me, I direct the Sights to B 3, and then find the Needle cut 327° , which I enter in the middle Column under © 1. thus, B 327° .

Note, By the Instrument used in this Example, the Bearing is accounted from the North, Westward quite round to 360° .

The Observation being made of the Line's Position, which I am about to measure, the next thing is to lay the Chain from this Station A in a right Line towards the next Station B 3; which being done, I let it lie, till I have entred the Occurrences in this Chain's Length, *viz.* I measure the Distances of the Chain from the Brow of each Ditch, which I enter in the outside Columns, that on the right Hand of the Chain in the right Hand Column, that on the left in the left Hand Column, and also the Names of the Persons who own these Lands abutting; or if these Lands are some of those which I am about to survey, I enter the Names of them, and in all Cases express to which Land the Hedge belongs.

These Precepts I shall not repeat, though I shall ever make use of them; but if I use any other, I shall lay them down the first time I meet with them in this Example, but not afterwards.

First then, I enter 0 in the middle Column, and 20 in the right Hand one, and 20 in the left, denoting, that at no Distance, or at the Instrument, the Ditch on the right Hand

Hand is 20 Links from the Chain, and that on the left also 20. In the right Hand Column I write *William Wary's Land, Hedge to Wary*; and in the left, *Lord Title's Land, Hedge to Lord*; because the Land and Hedge on the right is *Wary's*, and that on the left *my Lord's*.

Being come to *a*, I am right against the South Hedge of *Hazle Spring*, and also of *Woodfield*, and there find the Distance from the Ditch on the right Hand to be 25, and on the left to be 20, and that afterwards the Hedge on the right Hand belongs to *Hazle Spring*, and on the left to *Woodfield*. Therefore I enter in the middle Column 65, and in the right Hand Column 25, *ag. Hedge on Hazle Spring, Hedge to Spring*; and in the left 20, *ag. Hedge on Woodfield, Hedge to Field*.

Here may be observed, that I always measure these Off-sets or Distances of the Chain from the Hedge (with my ten Link Staff, which I therefore call my *Off-set-Staff*) perpendicular to the Chain, and so far till I come to that Brow of the Ditch, which is farthest from the Stem of the Hedge: And that here by the Brow of the Ditch, I mean the determined Distance of five Links from the Stem of the Hedge. And in order to lay this Staff perpendicular to the Chain, it would be convenient to have two Pieces at one End of it at right Angles, like the Squares used on a Drawing-board; and these Pieces, for Conyenience in Carrriage, may

be

be made to fall into the Staff, by Springs like a Clasp-Knife.

Having entered my Observations in my first Length of my Chain, I observe what Place of the Ground is exactly under the Center of my Instrument, by dropping a Musquet Bullet; then I remove my Instrument, and in that Place fix, as upright as I can, a Station-Staff, and then proceed with the Chain.

And because in the second and third Lengths of the Chain I meet with no sensible Turns in the Hedge, nor other material Occurrences, I go on to lay it a fourth Time, and there against 45 Links I find a Bend in each Hedge; where on the right Hand the Brow of the Ditch is 50 Links distant from the Chain, and on the left 40; therefore in the middle Column I enter 345 (denoting 3 Chains 45 Links) and in the right Hand Column 50, and in the left 40.

And here may be observed, that I take Off-sets only at each End of such Parts of a Hedge, as run very nearly strait, omitting the intermediate Parts; since when the Extreams of a right Line are given, that right Line itself is also given: So here, though the Distance of the Hedges from the Chain between *a* and *b* continually vary, yet I only take the Off-sets at *a* and *b*, since these are sufficient. But when the Hedge runs on with a continued but irregular Curvature, I take Off-sets at every Chain or half Chain's Length, or perhaps oftner, as the Thing requires. But when the Curvature is regular,
I take

I take its Extremities by Off-sets, and express its Nature by a Sketch, in the outside Columns.

In going on from *b* towards *B*, when I am come to *c*, the Chain touches the Brow of the left Hand Ditch, against 20; then I ask the hindmost Man, How many Arrows he hath? he answers 5; then I enter in the middle Column 520 (denoting 5 Chains 20 Links) and in the left Hand Column 00, denoting that the Brow of the Ditch is at no Distance from the Chain. The Chain still lying against 40 Links, I find a Bend in the right Hand Hedge, where the Ditch is distant from the Chain 50 Links.

Now it may be observed, that I frequently ask the Follower of the Chain, and also the Leader, How many Arrows they have? especially when I am about the Off-set or other Occurrence, partly to know the Number of the Chains, and partly to prevent the Loss of an Arrow; for this always raises a Doubt of the Length, and must be removed before we proceed; and lest when a Stick is dropp'd, another may be pick'd up in its Room, I always give my Arrows some Marks of Distinction.

If the Sum of the Arrows in both my Assistants Hands are less than nine, then the last Length must either be re-measured, since it's doubtful, or else the Surveyor must step it, and thereby discover which dropt it: And this, with a little Practice, he will easily do by counting his Steps, and using himself to step about the same Distance each Step; and

and by loosing a Button of his Coat when he hath gone as many Steps as (by Experience he knows) carry him the Length of a Chain. And hence he may know exactly the Number of the Chains, though he cannot perhaps find exactly the odd Measure. But the Number of Chains is sufficient, because the Error by dropping Arrows always falls in whole Chains.

In like manner at the Length of just 800, because the Chain touches the right Hand Ditch, and is distant from the Bend in the left Hand 40 Links, I enter in the middle Column 800, in the right Hand Column 00, and in the left 40.

Then I continue on to my Station Staff at B³, which I find to be at the Length of 825, where, because there is no Bend in the Hedge, nor other material Occurrence, I enter 825 in the middle Column, and under it I draw a Line, denoting that this Length, and all the Occurrences therein, are observed and entered in the Field Book.

Since I have endeavoured to be plain and easy in this first Length; so shall I, in the following Part of this Example, be as concise as I can, unless where I meet with Matter not before spoken of; referring the Reader rather to the Field Book and Explanations, than tiring him with Repetitions.

Being come to B³, I there so plant my Instrument by Help of my Bullet, that its Center is directly over the Hole, which the Station Staff stood in; and I send my Station
Staff

Staff forwards, as far as I can conveniently see it as to C.

Now with the Beginning of the Degrees towards me, I direct the fixed Sights back to the Staff at A, and then screw the Instrument fast: And then with the Flower-de-luce towards me, I direct the Index to the Staff at C, and there find, that the End of the Index next me, cuts $202^{\circ} 45'$, and the South End of the Needle points at $304^{\circ} 15'$. Therefore I enter in the middle Column of my Field-Book, $\odot$ 2, and under it $\angle$ $202^{\circ} 45'$; and next under this *B* $304^{\circ} 15'$; denoting, that at the second Station, the Angle made, is $202^{\circ} 45'$, and the Bearing of the second Length is $304^{\circ} 15'$.

But before I proceed, I examine these Numbers thus: To the Bearing of the last Station 327° , I add the constant Number 180, and from the Sum 507° , I subtract the present Bearing $304^{\circ} 15'$; and find the Remainder $202^{\circ} 45'$, exactly equal to the Angle.

Or else, to the Angle $202^{\circ} 45'$, I add the present Bearing $304^{\circ} 15'$; and from the Sum 507° subtract the constant Number 180, so shall the Remainder 327° be the Bearing of the last Length exactly, as taken at the last Station.

And this Operation I place in the outside Column against the same Angle and Bearing, to signify, that the Angle and Bearing have been compared, and do agree.

But if these Numbers thus compared, do not agree, the present Angle and Bearing
F must

must be examined and corrected ; and if, after such Examination, they do not agree, there is an Error in the last Bearing, which may be taken again ; thus,

The Instrument standing in the same Place, I direct the Index, the Flower-de-luce being from me, to the last Station-staff at A ; and then will the South End of the Needle point at the same Degrees which it did when the Instrument stood at A, and the Index was directed to B³.

Having thus taken, entered and examined the Angle and Bearing, I proceed with my Chain, and find the Lengths and Occurrences to be as you see them in the Field-Book.

Then fixing my Instrument, as before taught at C ; I send my Station-staff forward to D, and observe and enter, and prove the Bearing and Angle at C ; and then stretching my Chain towards D, I find at the Length of 250, a Gate on my right Hand, and at 260, at the Distance of 10 Links, the Corner of *Hazle-Spring*. Therefore in the middle Column I enter 250, and right against it, in the right Hand Column, I write *Gate* ; Again, in the middle Column, I enter 260, and right against it, in the right Hand Column, 10 *Corner*. And then proceed to the Station-staff at D.

Having finished the Length CD, and fix'd the Instrument at the fourth Station D, I do not go up the Lane towards E, but turn off towards L ; in order to close in *Hazle Spring* and *Spring Close* ; always observing

erving this Law, viz. Never to make a Tour greater than Necessity requires, but always to close as often and soon as possible.

Therefore having sent a Staff to L; I observe, enter and prove the Angle and Bearing at D.

Here may be observed, that when I came to K in the first Length, the Hedge on the left Hand belonged to *Woodfield*, and not to the Lane; and therefore I entered in the left Hand Column, *Hedge to Field*; and since this Note, the Hedge on the left Hand hath continued to belong to the same *Woodfield*; therefore I have not repeated that Occurrence. But in going from D to L, at the Length of 15 Links, I am against the Corner of *Long Mead*, and 10 Links distant from it, and then the Hedge belongs to *Long Mead*. Therefore after © 4. 7 259° 20', B 261° 10', I enter in the middle Column 15, and on the left Hand 10 *Corner*, then on *Long Mead*, then *Hedge to Long Mead*.

But because on the right Hand we have still *Hazle Spring*, and the Hedge is still to the Spring, and because these have been always on the right Hand since I first entered them; I go on without any farther Remark, till I meet with a different Occurrence.

Being come to L, I observe, enter and prove the Bearing and Angle, and then proceed to M. At M I observe and proceed in like Manner to N. But at N, the seventh Station, instead of going on in the

Lane, I proceed to close in *Hazle Spring*, and therefore send a Station-Staff to O in *Spring Close*.

Therefore at the seventh Station N in the Lane, having observed, entered and proved the Angle M N O, and the Bearing of the Line N O, and directed the Chain from N towards O ; I find the Chain cuts the Brow of the Ditch at 10 Links distant from N ; therefore in the middle Column I enter 10 *Int.* denoting the Chain's intersecting the Hedge, and before I write *In Spring Close*, denoting that the Land we are in is called *Spring Close* ; and in the right Hand Column, but the next Line, I write *Hazle Spring*, and under this, *Hedge to Spring*, denoting that the Land on our right Hand is *Hazle Spring*, and that the Hedge belongs to the same. Then I proceed to observe, measure and enter those Occurrences as they are found in the Field-Book, till I come to O.

At O, I observe, enter and prove, and proceed as usual towards Q ; noting that at the Length 720 the Chain did cut the Hedge in the very Corner of the Fence ; and therefore enter in the middle Column 720 *Int.* and in the right Hand Column 00 *Corner*, and then in the middle Column I write, *In William Wary's Land* ; and so proceed to Q.

Being come to Q, the ninth Station, I send a Station-Staff towards A ; and then observe, enter and prove my Angle and Bearing ; and so proceed with the Chain, entering all Occurrences, as in the Field Book, till, coming to the Length 830, I

find

find myself right against the Corner of *Hazle Spring*, and 43 distant from it; which being entered as you see in the Field Book, I write in the middle Column * *Close-Hazle-Spring*, denoting that the Extremity of this Off-set co-incides with the first Off-set taken to *Hazle Spring*.

Having thus compleated *Hazle Spring*, I return to N, my Station in the Lane, according to that general Law I always observe, of working in a Lane, and according to that Law of closing as often as possible.

Now, if I turn back the Leaves of my Field Book, I find the Station, immediately before my coming into *Spring Close*, was by Number the seventh. Therefore, in my Field Book, I enter © 7.

But here may be observed, That whensoever I design to return to the same Station, before I left it, I cut a Turf from the Hole where the Staff stood, or leave some other Mark, whereby I may exactly find it again readily; and in the Field-Book to the Mark ©, I prefix the Letter R: by which, and the other concomitant Notes, I readily discover the Number of the Station.

Having now planted my Instrument a second time at N, and sent a Staff forward to R, I observe the Angle MNR, made by the Line NR, I am next about to measure, and the Line MN, that which measur'd immediately before I came to N the first time.

And this I always make a constant Law, viz, To observe the Angle with that Line

which was measured immediately before I came to the Station, where I took the Angle the first time. So here I observe the Angle made with MN, and not with any other as ON, and therefore in proving the Angle MNR, I use the Bearing of MN taken at M.

Now having taken, enter'd and prov'd the Angle MNR, and the Bearing of NR, I go on with the Chain towards R, entering the several Occurrences as you find them in the Field-book.

Being come to R, the tenth Station, tho' my Design is to inclose *Spring Close*, yet because the last Length, continued strait forwards, will take the South Hedge of *Long-Mead*; in the middle Column I enter $\odot$ 10, $\angle$ 180, and then direct the Leader of my Chain to lay it right forwards by help of the Stations R and N; and accordingly I enter the Occurrences of that Length, as you see in the Field-book.

This finished, I return to R, and sending a Station-staff to S, I enter again $\odot$ 10, and the Angle and Bearing at R, and so proceed to S.

And then from S to T, and so from T the 12th Station to P, inclosing *Spring Close*.

Spring Close being finished, I return to my fourth Station at D; and then send a Station-staff forwards to E, and then under $\odot$ 4, observe and enter the Bearing of DE, and the Angle CDE; and then by the Bearing of CD, taken at the Station C, immediately before I came to D, prove the Angle CDE,

and proceed with the Chain, entering all Occurrences as usual.

Being come to E, I send the Station to F, in order to close in *Woodfield*. Now, after I have observed and entered the Angle and Bearing at the Thirteenth Station E, when I come to prove them, I find by adding 180° to $353^{\circ} 15'$, the Bearing of the Line which brought me to this Station; and when from the Sum $533^{\circ} 15'$, I have subtracted 82° , the present Bearing, I find the Remainder to be $451^{\circ} 15'$, a Number greater than the 360. Now as oft as this happens, I lessen this Number by 360 Degrees, and so will the Remainder be, as in this Example, $91^{\circ} 15'$, the present Angle exactly.

Then entering the Occurrences, I proceed to F, and in like manner from F to G, from G to H, from H to I, and then from I, the Seventeenth Station, to K, thereby inclosing *Woodfield*.

This done, I return to E, and there because I can continue my Length D E, right forwards conveniently, I enter $\odot 13$, $\angle 180^{\circ} 00'$, and then go on to V.

And then entering Angles, Bearings, and other Occurrences, I proceed from V to W, and from W to X, the 20th Station.

Being come to X, and having entred $\angle 234^{\circ} 20'$, and $B 307^{\circ} 40'$, then after I have added $180^{\circ} 00'$ to the last Bearing $2^{\circ} 00'$, I find the Sum $182^{\circ} 00'$ is less than $307^{\circ} 40'$ the present Bearing: In such Cases I always add 360 to the Sum 182, and then from the Result, taking the present Bearing

307° 40', the Remainder will be, as in this Example, 234° 20', the present Angle.

Then I proceed to Y, and from Y to Z.

Being come to Z, the 22d Station, in order to enclose *Long Mead*, I go off to α , from α to β , from β to γ ; where, because the several Bends of the River cannot so commodiously be taken without it, from γ I go off to δ ; and then from γ to ϵ , from ϵ to ζ , from ζ to η , and from η the 28th Station, to θ ; thereby inclosing *Long Mead*. And then return to Z.

Being come to Z, I find it convenient to continue my Length strait forwards; and therefore under $\odot$ 22, I write $\angle$ 180, and so go on to κ , from κ to λ , from λ to π ; and then in order to inclose *Butts Close*, I go off from π , the 31st Station, to ρ , and ρ to σ .

Then returning to π , I go on to A² the 33d Station, and then, in order to close the *Home Close*, I go off to B², and so then to C², and D².

Returning then to A², I go on to E², from E² to F², from F² to G², and G² to H², the 39th Station.

Being come to H², in order to close in *Mottle Mead*, I go off to I², from I² to K², from K² to L², the 42d Position, and from L² to M², and so is *Mottle Mead* finished.

Then in order to inclose *Hazle Wood*, I go from L² to N², from N² to the Angle at F, and so is *Hazle Wood* finished.

Then I return to H² the 39th Station, and thence go to O², and from O² to P², the 45th Station.

And

And now, in order to close in *Hazle Field*, I go from P^2 to Q^2 , and from Q^2 to T^2 .

Which being done, I go from P^2 to R^2 , and from R^2 to S^2 ; and so the whole is finished, as you find it in the Field Book; and as far as relates to the Field Work.

It remains to shew, how this Work may be plotted without any regard to the Memory; nay, though it were survey'd by one Person how it may be plotted by another who never saw the Land; provided that the Person who survey'd it, hath strictly observed the Laws here laid down. And I do affirm, that any Method of keeping a Field-Book, which lays a Burthen on the Memory, or by which, a Person remote from the Land, cannot plot it, is imperfect, and ought not to be practised.

But it may not be improper, to advertise the Reader, That there is one Thing absolutely necessary to be taken Notice of, in observing with any of the foregoing Instruments, *viz.* That the Plate lie always parallel or very near parallel to the Plan of the Horizon.

Secondly, He ought to allow for the Difference between ascending and descending Lengths, when compared with the horizontal Length.

For it is evident, That the Length measured up an Ascent, or down a Descent, will be always greater than the horizontal Lengths, which only are the Measures which ought to be entered, either for Casting or for Drawing the Plans of any Parcel of Land what-

†

soever;

soever: Since these ascending Measures, if laid down, would crowd the adjacent out of their Places.

And since these Things are required very frequently, many Times in going upon one Ascent, and consequently ought to be performed in the Field, in order to make a proper Entry in the Book; I would have the Practitioner be provided with such a *Theodolite*, as will perform without Compasses, Rules, Sectors, Tables, &c. these useful Practices, or without any further Observations than what is required to take the Angle only. Such *Theodolites* may be made, not only to perform these, but also to shew by Inspection, the Height of any standing Stick of Timber, without any Calculation, tho' the Stick stood on level, rising, or falling Ground: Or the Length of any Arm out of Reach; or Height of any Steeple or Hill: Or by it a Level proper for the conducting of Water; very proper for all Surveyors in general.

Tho' I do design to give you a Specimen of this improved Instrument, after this Example, in all its Conveniencies, I could not pass it by in this Place, lest the Reader should over-look it.



Obfer-



Observations and Dimensions of Lands
 lying in the Parish of — in the
 County of — Part of the Estate
 of —

February the 2d. 1725.

*Beginning at the Lane leading from Hardly to
 Roughton.*

	⊙ I	
On Ld. Title 20	B 327. 00	20 On Will. Wary
Hedge to Lord	0	Hedge to Wary
ag. Hedge 20	65	25 ag. Hedge
On Woodfield		On Hazle-spring
Hedge to Field		Hedge to Spring
40	345	50
00	520	
	540	50
40	800	00
	825	

[76]

327. 00
180. 00

507. 00
304. 15

202. 45

⊙ 2

7 202.45
B 304.15

15

240
250 |

10

⊙ 3

304. 15
108

484. 15
340. 30

143. 45

L 143.45
B 340.30

250
260
270

Gate
10 Corner

20

340. 30
180

520. 30
261. 10

259. 20

R ⊙ 4

7 259.20
B 261.10

15

Corner 10
On Long Mead
Hedge to Long
(Mead

15

220

⊙ 5

261. 10
180

441. 10
284. 20

156. 50

L 156.50
B 284.20

10

165

10

[77]

284. 20
180
464. 20
257. 30
206. 50

⊙ 6

7 206.50
B 257.30

10 230 10 against Hedge
On Spring Close
Hedge to Spring Close

240

257. 30
180

R ⊙ 7

7 264.30
B 173.00

437. 30
173
264. 30

10 Int.

In Spring Close
On Hazle Spring
Hedge to Spring

135

07

245

15

173. 00
180
353. 00
150. 45
202. 15

⊙ 8

7 202.15
B 150.45

154

11

335

50.

550

35

720 Int 00 Corner

In William Wary's Land
825

[78]

150. 45
 180

 330. 45
 90. 45

 240. 00

⑨
 7 240.00
 B 90.45
 90
 510
 640
 755
 830

20
 05
 70
 15
 43 Corner
 Close Hazle-spring

Taken from ⑥
 257. 30
 180

 437. 30
 274. 45

 162. 45

⑦
 L 162.45
 B 274.45

40
 15 230
 50 230
 35 260
 350

Gate
 05
 10 against Hedge &
 Corner of Spring-
 (close.

R ⑩

7 180.00
 B 274.45

0
 30 60
 20 100
 00 160

On Tho. Coles
 20
 40

[79]

$\begin{array}{r} 274.45 \\ 180 \\ \hline 454.45 \\ 208.20 \\ \hline 246.25 \end{array}$

In Tho.

$\begin{array}{r} \textcircled{C} 10 \\ 7 246.25 \\ B 208.20 \end{array}$

10 Int.
Cole's

Land
Hedge to Spring
Close

$\begin{array}{r} 300 \\ 340 \\ 370 \end{array}$

$\begin{array}{r} 100 \\ 10 \end{array}$

$\begin{array}{r} 208.20 \\ 180 \end{array}$

$\begin{array}{r} 388.20 \\ 180 \\ \hline 208.20 \end{array}$

$\textcircled{C} 11$

$\begin{array}{r} 7 208.20 \\ B 180.00 \\ 00 \\ 630 \\ 680 \end{array}$

$\begin{array}{r} 18 \\ 15 \text{ Corner} \end{array}$

$\begin{array}{r} 180.00 \\ 180.00 \\ 360.00 \\ 85.00 \\ \hline 275.00 \end{array}$

$\textcircled{C} 12$

$\begin{array}{r} 7 275.00 \\ B 85.00 \\ 20 \end{array}$

$\begin{array}{l} \text{Corner} \\ \text{on Spring Close} \\ \text{Hedge to Spring-close} \\ 20 \text{ Corner} \\ \text{Close-spring-close} \end{array}$

$\begin{array}{r} 400 \\ 870 \end{array}$

$\begin{array}{r} 00 \\ 20 \end{array}$

Taken

[80]

Taken from © 3

© 4

340. 30
180

167.15

520. 30
353. 15
167. 15

B 353.15

On Woodfield
Hedge to Woodfield

10

10 Corner of
Long Mead
Hedge to Long Mead

Gate 20

440

00

R

© 13

353. 15
180

91.15

B 82.00

533. 15
82. 00

20 Int.

451. 15
360

20

In Woodfield
15 Corner of Hazel-
(Wood

91. 15

Hedge to Wood

550

15

82. 00

© 14

180

99.00

B 163.00

262

00

163

10 Gate
On Wood-Close
Hedge to Woodfield

99

550

30

[81]

163. 00
180
343
93. 15
249. 45

⊙ 15
7 249.45
B 93.15

35 00 Corner
430 130
600 100
610 50 against Hedge and
Corner of Woodfield
On Lord Title's Land
Hedge to Title
835 10 Corner

93. 15
180
273. 15
195. 40
77. 35

⊙ 16
L 77.35
B 195.40
00
320
500
650
742

00
210
00
135 Corner

195. 40
180
375. 40
246. 30
129. 10

⊙ 17
L 129.10
B 246.30
00
610

15
15 Corner
Close Woodfield

against Hedge 20
On Hazle Wood
Hedge to Wood

⊙ 13
7 180.00
B 353.15
20

On Long Mead
Hedge to Ditto

25 140 00

G

353.

[82]

353. 15		⊙ 18	
180		7182.45	
533. 15		B 350.30	
350. 30			
182. 45	10	360	20
	10	445	20
350. 30		⊙ 19	
180.		⌊ 168.30	
530. 30		B 2.00	
2. 00			
528. 30			
360			
168. 30	00	100	20
	25	255	05
	25	350	00
	15	440	10
	10	520	20
	30	595	30
	30	663	70
2. 00		⊙ 20	
180		7234.20	
182. 00		B 307.40	
360			
542. 00			
307. 40			
234. 20			
Gate 75		60	
30		170	
against Hedge 20		215	00
On Butts Close			
Hedge to Close			
	00	450	20

307.

[83]

307. 40
180
487. 40
287. 00
200. 40

⊙ 21

7200.40
B 287.00

20 150
20 260
75 275
380
70 400

Gate

00 against Hedge and
Corner of Long Mead
On Walter's Mea-
(down)

25

510

287. 00
180.
467. 00
186. 20
280. 40

R ⊙ 22
7280.40
B 186.20
10 Int.

In Walter's Meadow
110 Corner
On Long Mead
Hedge to Long Mead

27

360 15
540 190
735 10

G 2

186

[84]

186. 20
180
366. 20
166. 15
200. 05

⊙ 23
7200.05
B 166.15
10 Int.

In Long Mead

Corner 10
On Trout Beck
Common Mead 00

20
50
10 150
10 235
245

166. 15
180
346. 15
111
235. 15

⊙ 24
7235.15
B 111.00

10 40
20 105
00 255
25 345
460

111. 00
180
291
229. 20
61. 40

R ⊙ 25
L 61.40
B 229.20

30 80 30
30 120
150 35
25 160
170 50
10 200 40

[85]

$\begin{array}{r} \circ \\ 111.00 \\ 180 \\ \hline 291 \\ 162.30 \\ \hline 128.30 \end{array}$

$\begin{array}{r} \odot 25 \\ 7128.30 \\ B 162.30 \\ \hline 15 \quad 145 \\ 50 \quad 190 \\ 10 \quad 430 \\ 30 \quad 535 \\ \quad 585 \end{array}$

$\begin{array}{r} 162.30 \\ 180 \\ \hline 342.30 \\ 251.30 \\ \hline 91 \end{array}$

$\begin{array}{r} \odot 26 \\ L 91.00 \\ B 251.30 \\ \hline 45 \quad 70 \\ 00 \quad 175 \\ \quad 270 \end{array}$

$\begin{array}{r} 251.30 \\ 180 \\ \hline 431.30 \\ 290.30 \\ \hline 141.00 \end{array}$

$\begin{array}{r} \odot 27 \\ L 141.00 \\ B 290.30 \\ \hline 67 \quad 205 \\ 70 \quad 280 \\ 15 \quad 360 \end{array}$

G 3

290.

[86]

8 /
290. 30
180

470. 30
179. 30

291. 00

⊙ 28

7 291.00
B 179.30

On Tho. Cole's
Hedge to Cole

10 00
10 150
20 300
10 400
10 510

Clofe Long Mead

⊙ 22

7 180.00
B 287.00

In Roughton Common
Corner. 00 30
65

287. 00
180

⊙ 29

467
2. 10

L 104.50
B 2.10

464. 50
360

104. 50

On But's Clofe
Hedge to Clofe

86 230
00 480
65 635

2° 10'

[87]

° 2. 10
180
 182. 10
93. 10
 89. 00

⊙ 30
 ∠ 89.00
 B 93.10
 65 Int.
In But's Close

On Roughton Com.
65 Hedge to Close
 100
 350
 750
835
 100
 100
 15

93. 10
180
 273. 10
167. 10
 106. 00

R ⊙ 31
 ∠ 106.00
 B 167.10
 0
590

20 On Home-close
Hedge to Home-close
 15

167. 10
180
 347. 10
220. 30
 126. 40

⊙ 32
 ∠ 126.40
 B 220.30
 0
 85
415

10
 10 *against Hedge*
On Hazle Wood
Hedge to Wood
 10
close But's Close

G 4

⊙ 31

[89]

Taken from © 31

© 33

93. 10
180.

273. 10
102. 00

171. 10

102. 00

108

282. 00

82.

200.

£ 171.10
B 102.

20 Int.

In Mottle

300

315

© 36

7 200.00

B 82.00

70

150

380

600

770

808

Mead

On Roughton Com-

25

(mon

65

10

60

15

15

10

© 37

£ 136.30

B 125.30

00

100

260

15

30

30 against Hedge

© 38

£ 103.40

B 201.50

00

255

270

On Ld. Title's Land

Hedge to Lord

60

125. 30

180

305. 30

201. 50

103. 40

[90]

201. 50
180
381. 50
279. 20
102. 30

R © 39
L 102.30
B 279.20
00
295
605
620

30 On Hazle Field
Hedge to Mottle
(Mead
35
15 Corner

279. 20
180
459. 20
177. 15
282. 05

© 40
7 282.05
B 177.15
370

10

177. 15
180.
357. 15
271. 50
85. 25

© 41
L 85.25
B 271.50
00
235

15

15

R © 42
7 180.00
B 271.50
20

15 against Hedge
On Hazle Wood
Hedge to Hazle Wood
15
close Mottle Mead

375

[91]



271. 50
180

451. 50
183. 00

268. 50 In
On Hazle Wood
Hedge to Wood

25
Corner 10

183. 00
180

363.
209. 30

153. 30

Corner 00

270

Corner of
Hazle Wood
and Woodfield

Taken from © 38

201. 50
180.

381. 50
185. 15

193. 35

In

© 42

7 268.50

B 183.00

15 Int.

Hazle

Field

375

760

790

© 43

L 153.30

B 209.30

230

445 Int.

Wood

Close

650

860

© 39

7 196.35

B 185.15

30

20 Corner

39 Int.

Hazle

Field

On Ld. Title's Land
Hedge to Lord

400

165

365

100

1100

10

185

[92]

• /
185. 15
180
365. 15
171. 30
193. 45

171. 30
180
351. 30
270. 30
81

270. 30
180
450. 30
338. 00
112. 30

close Hazle Field

⊙ 44
0 /
7 193.45
B 171.30
200
345
440
520

R ⊙ 45
L 81.00
B 270.30

15
100
340
650
740
990

⊙ 46
L 112.30
B 338.00

00
200

110
30
70
20

45 On Wood Close
Hedge to Wood Close

65
95
75
80
13

10
15 ag. Hedge
On Hazle Wood

[93]

	⊙ 45	
	° /	
	7 180.00	
	B 171.30	
	15	10 Corner
	35 Int.	On Ld. Title's Land
In	Wood	Hedge to Title
	255	Close
	300	30
	⊙ 47	
	⌒ 100.30	
	B 251.	
B /		
171. 30		
180		
351. 30		
251. 00		
100. 30		
	25	100
	240	230
	330	175
	310	125
	640	00
	680	120 against Hedge
		On Woodfield



SECT.



S E C T. VII.

To protract the Observations contained in the preceding Field-Book.



IR T, I draw parallel right Lines, as those in the Scheme mark'd N S, representing Meridians or North and South Lines, at a Distance from one another, not exceeding the Breadth of the diametrical Part of the *Protractor*.

Then picking out some convenient Place to represent the first Station, as A; my Field-book being open before me, I lay the Center of the *Protractor* on the Point A, and the Diameter parallel to the Lines NS, and the beginning of the Degrees downwards, because the Bearing is more than 180; then against 327 Degrees, I make a Mark with my *Protracting Pin*, to which I draw an obscure Line from A, representing the Chain-line from the Station A to the Station B.

Then to this obscure Line, I lay the Edge of my *Plotting Scale*, the beginning of the Divisions co-inciding with A, and increasing towards the next Station B, and because the
Off.

Off-sets, in the first Length, are taken at the Distances 65, 345, 520, 540, 800, 825; therefore, against these Numbers on the Scale, I make Marks in the obscure Line close to the Edge of the Scale.

This done, I turn my Scale perpendicular to the obscure Line, and apply it successively to these several Points, and there prick off the Lengths of the several Off-sets on their respective Sides of the obscure Line; so at A, I prick off 20 on the right Hand, and 20 on the left; at the Length 65, which is the next Point, I prick off 25 on the right Hand, and 20 on the Left; and at the next Point, which is at the Distance 345, I prick off 50 on the right Hand, and 40 on the Left; at the fourth Point, which is at the Distance 520, I prick off 00 to the left Hand; at the fifth Point, which is at the Distance 540, I prick off 50 to the right Hand; at the next Point, which is at the Distance 800, I prick off 00 to the right Hand, and 40 to the Left; at the last Point, because no Off-set was taken, I lay none down.

And now, if Lines are drawn from Point to Point on each Side of the obscure Line, they will represent the Fences as was required. But when the Off-set is 00, as in the fourth and sixth Distances, those Points, to prevent being over-look'd, should be mark'd with a black-lead Pencil, or something else, which may be easily rubb'd out again.

At the second Distance, where we were against the South Fences of *Woodfield* and *Hazle Spring*, with a black-lead Pencil draw

two short Lines, cutting the Lane, to denote that the South Fences come up to the Lane, and will hereafter be of use in closing these Plots.

Having thus finished my first Length, I produce it, if occasion require from B, both Ways, till it is as long each Way as the *Radius* of the *Protractor*. Then I place the Center of the *Protractor* on B, and thereon turn it about, because the Degrees of the next Angle are more than 180, till the Beginning of the Degrees of the *Protractor* are contrary to the last Station A, and the Diameter coincident with A B. Then close to the Edge of the *Protractor*, right against $202^{\circ} 45'$, I make a Mark with my *Protracting Pin*, and to it from B draw an obscure Line representing the Chain Line from B to C.

Then I turn the *Protractor* about, the Center still coinciding with B, and because the Bearing is more than 180, the Beginning of the Degrees towards S, and the Diameter parallel to the Meridians; and then, if you have truly wrought, the Line BC before drawn, will meet the Limb of the *Protractor* against $304^{\circ} 15'$, the Bearing of the Line BC.

But if it doth not, the Line BC is not in its true Position, and must be corrected before you proceed.

Or thus; The Center of the *Protractor* coinciding with B, I turn it about till the Beginning of the Degrees is towards S, because the Bearing is greater than 180, and till

till the Diameter lies parallel to the Meridians; and then close to the Edge of the *Protractor*, with my *Protracting Pin*, I make a Mark against $304^{\circ} 15'$, the Bearing of the Line D.C, and to it from B draw a strait Line representing the strait Line B.C. Then turning the *Protractor* about on the Center C, and because the Angle there taken was $202^{\circ} 45'$, more than 180, I turn the Beginning of the Degrees of the *Protractor* contrary to the last Station A, and the Diameter to agree with A.B; and then will B.C meet the Limb of the *Protractor* against $202^{\circ} 45'$, if the Bearing is truly laid down.

And thus the Plot may be laid down by the Bearings, and examined by the Angles.

Then to this obscure Line, I apply the Edge of my *Plotting Scale*, the Beginning of the Divisions coinciding with the present Station B, and the Numbers increasing towards the next C; and then close to the Edge thereof, against 240, 250, the Lengths where the Off-sets were taken, I make Marks with my *Protracting Pin*. This done, I turn my Scale perpendicular to the obscure Line, and at 240, I prick off 15 to the left Hand, and against 250, which gives the Point G, I prick off 10 to the right Hand, as the Field-Book directs. Now continuing the Fences to these Off-sets, I shall have finish'd the second Length from B to C.

The second Length thus finished, I produce it, if Occasion require, from C both ways, till the Length each way be at least equal to the *Radius* of the *Protractor*. Then I

H

place

place the Center of the *Protractor* on C, and because the Degrees of the Angle at C are less than 180, I lay the Beginning of the Degrees of the *Protractor* towards B, the last Station, and the Diameter on B C. Then close to the Edge of the *Protractor*, with my *Protracting Pin*, I make a Mark against $143^{\circ} 45'$, the Quantity of the Angle at C, and to it draw an obscure right Line from C, representing the Line from C to D.

Then turn the *Protractor* about, its Center still coinciding with C, because the Bearing is more than 180, the Beginning of the Degrees towards S, and the Diameter parallel to the Meridians, and then if you have work'd truly, the Line C D before drawn, will meet with the Limb of the *Protractor* against $340^{\circ} 30'$, the Bearing of the Line C D.

But if not, the Line C D is not in its true Position, and must be corrected before you proceed.

From the laying down these two Angles and Bearings, it appears how Errors often happening in Practice, may be prevented.

The general Laws I observe herein are Three, *viz.*

1. I lay the Diameter of the *Protractor* on that Line which brought me to the present Station, where the Angle, about to be laid down, was taken.

2. I lay the Beginning of the Degrees of the *Protractor* towards the last Station, when the
the

the Angle is less than 180 Degrees ; but the contrary way, when the Angle is more.

3. In laying down or examining the Bearing, I lay the Beginning of the Degrees of the *Protractor* Northwards, when they are fewer than 180 ; but Southwards, when more.

In like manner I lay down and examine the Angles and Bearings taken at D, L, M, N, O, Q, the 4th, 5th, 6th, 7th, 8th, 9th Stations, and also the corresponding Lengths and Occurrences. But in the last Length Q A, having at the Length 830 laid off an Off-set of 43, it gives exactly that Corner of *Hazle-spring*, which was noted down in the first Length in the Lane ; which proves that the Angles and Lengths inclosing *Hazle-spring*, are truly laid down. But if the Extremity of the last Off-set in the Length Q A doth not coincide with the Extremity of the second Off-set A B, both denoting the South-West Corner of *Hazle-spring*, the Lengths and Angles designed to inclose the same *Hazle-spring*, are not truly laid down, and therefore must be examined and corrected before you proceed.

Now © 7, being mark'd with 7, a Number not greater than 9, the Number of the last Station, being the next Work noted in my Field Book ; I return to © 7 in my Draught, and there with M N, the Line which I measured immediately before I came to N, I make the Angle M N R

H 2

162°.

162°. 45', and the Bearing of N R 274°. 45', as noted in the Field Book, and then proceed to lay down the Off-sets and other Occurrences, at their proper Lengths and Distances.

Having finished N R, I find next following in my Field Book © 10, which because it is greater than 8, the Number which immediately follows 7, the Number of the last Station; and because I find no Station already laid down, mark'd with a Number so great as 10, therefore conclude, that the Station R, where I now am, is to be numbered 10; and from thence proceed to lay down and examine the Angle and Bearing at R, as usual.

The Laws I observe in these Cases are,

1. To number with black Lead all the Stations I have already laid down in my Draught, and also to express those Numbers successively after one another, in a Piece of waste Paper, which I examine as often as I please.

2. If I come to a Station whose Number doth not immediately succeed the Number of the last Station, but is greater than the greatest of those Numbers noted in my waste Paper by an Unite; then at the Station now arrived at, I lay down and examine the Bearing and Angle with the Line I measured immediately before I came to this Station. And this Station I number as denoted in my Field Book.

3. If

3. If I come to a Station, whose Number doth not immediately succeed the Number of the last Station, but is greater than the greatest of those Numbers noted in my waste Paper by more than an Unite, then some Omission hath arose in my waste Paper, and must be rectified before I proceed.

4. And lastly, If I come to a Station whose Number is already entred in my waste Paper, then I return to that Station in my Draught, and there lay down and examine the Bearing and Angle with the Line, measured immediately before I came to this Station, the first Time.

Now the next Observation I meet with in my Field Book, is again $\odot 10$; therefore again at $\odot 10$, I lay down and examine an Angle and Bearing, as noted in the Field Book, and then proceed to lay down the Lengths and Off-sets of the Line R S, as I find in my Field Book.

Being come to S, I proceed to T, and from T to P, there closing with the Extremity of the Off-set at P, coinciding with the South-West Corner of *Spring-clofe*, and the South-East Corner of *Hazle-spring*.

This done, I find next in my Field Book $\odot 4$; therefore I return to $\odot 4$, and there proceed as my Field Book directs, till I come to Station 13; and because this is a Number greater, by an Unite, than 12, the Number noted in my waste Paper, I number it 13, and then proceed, as my Field Book di-

rects, to F, G, H, I, and K, there closing in *Woodfield* by the Extremity of the Off-sets there laid down.

This done, I next find © 13, and therefore, because already entered in my waste Paper, I return to © 13 in my Draught; and then proceed as before shewn, till I have plotted all the Occurrences mentioned in my Field Book: but the remaining Part hereof I leave for the Exercise of the Reader.

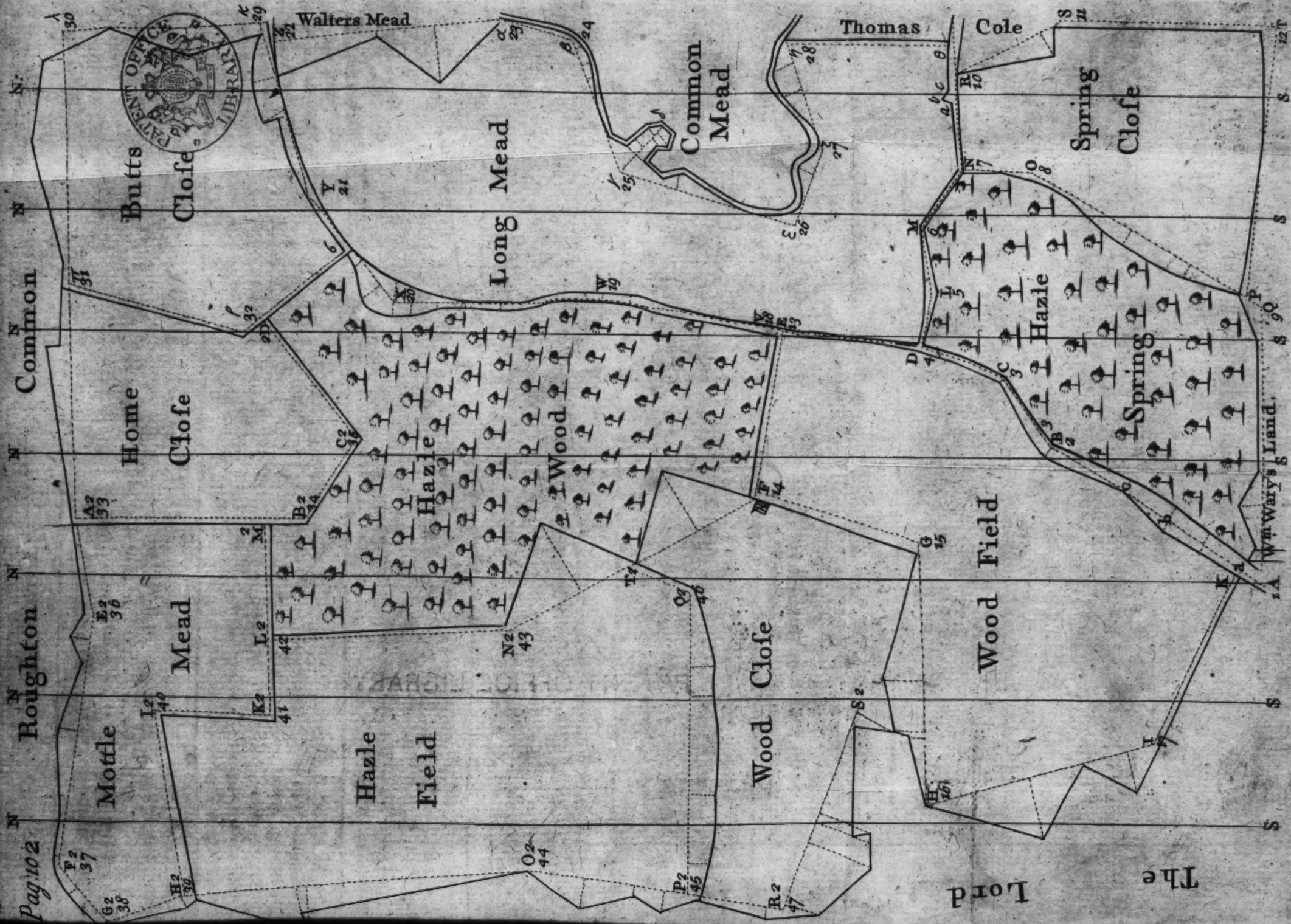
I think I need not detain the Reader with the Manner of transferring the Draught to his Vellom; of drawing a Scale and a Compass, ever allowing the Variation of the Needle; of entring the Contents of each Piece; and the Ornaments to be met with on every Draught.

I shall only add, That the Representation of the Hedges ought to be laid down on the same Sides of the Fences, that they are in the Land; and to be broke off where there are to be the Representations of Gates, &c.

That there ought to be imaginary Lines, both Vertical and Horizontal, denoted by Letters placed at the Top and Bottom, and also on the Sides, to be referred to by the Table of References; for the ready finding any Field, or Parcel of Land therein contained.

Lastly, I shall, in this Place, only add, That in all Performances of this Kind, Errors, for the most Part, arise from the Defects of Instruments, in the Framing, Dividing, and Contriving.

SECT,





A farther Use of the Theodolite (as now improved); conjointly with the Use of a Sliding Rule aptly divided; to measure Timber, either round, or hewn to a Square, or unequally squared. Also how to allow for Ascents or Descents by finding the horizontal Lines.



THE principal Difficulty in using this Sliding-Rule, is, in justly distinguishing the Value of each Division. And in order to this, it may be observed, That the Divisions on this Rule, may be distinguished into Three Orders, *viz.* The Longest, the Mean, the Shortest. And these distinguish their Value in a Tenth Proportion, as the Places of Numbers in Arithmetick.

So that, if the longest represent Hundreds, the mean will represent Tens, and the shortest Units.

H 4

And

And if the longest represent Tens; the mean will represent Units, and the shortest Tenth Parts.

Also, if the longest represent Thousands, the mean will represent Hundreds, and the shortest Tens; and in this Case, the Units must be estimated by the Eye, in judging at Divisions, only supposed to be drawn, because there is not Room enough.

The longest Divisions are generally numbered by the Figures, 1, 2, 3, 4, 5, &c. and when they are numbered thus, 1, 2, 3, 4, 5, 6, 7, 8, 9; 1, 2, 3, 4, 5, 6, 7, 8, 9, 1; the Line is called a double one. And when the longer Divisions are in Number only Ten, and numbered 1, 2, 3, 4, 5, 6, 7, 8, 9, 1; or numbered 5, 6, 7, 8, 9, 10, 20, 30, 40, 50; or broken so as to begin at any other Number, so as to contain only Ten long Divisions; the Line is called a single one. And these are called *Gunter's Lines*, from the Name of their Author.

But we may observe, That these Divisions represent equal Distances; yet, from their Use, cannot be so. Nor will be easily capable of equal Numbers of Divisions, in different Parts of the Rules; either of mean, between the longest, or of the shortest between the mean.

But in order to make this easy, here follows an Explanation of the Divisions laid down on the Foot Sliding-Rule, which may easily be applied to other Rules of greater Length; where the Multitude of the intermediate Divisions may be greater.

On

On the Slider, are Two of these double Lines, both alike; one of which moves against the fixed Line above, which is also exactly like to either of the other; and the undermost Line on the Slider moves against a single Line, beginning with the Numbers 5, 6, &c. and going on to 50.

If the first 1 be called an Unit, the following numbered Divisions, till you arrive at the Middle 1, will be Units. And the mean Divisions will be Tenth Parts.

If the first 1 be called Ten; the Figures 2, 3, 4, &c. immediately following it, will denote 20, 30, 40, &c. And the mean Divisions, that is the next longest in Order, will denote Units; the fifth of which is, for Distinction, made longer than the rest. And from 10 to 20, between each of these mean Divisions, the shortest denote each Two Tenths Parts; because the Distances between the mean Divisions, are divided into Five Parts; but if the Distances between these mean Divisions were divided by shorter Lines into Ten Parts, which is seldom done on Rules so short, each would represent one Tenth Part.

In like manner from 20 to 30, that is, between the Divisions mark'd 2 and 3, the same order follows; save that the Distances between the mean Divisions (because of their Nearness to one another) are divided into Two Parts only; and consequently each of these shortest Divisions will denote Five Tenth Parts; and the Eye must estimate the other Tenths not cut, but supposed to be cut between them:
Tho'

Tho' in larger Instruments, even here, and elsewhere, the shortest Divisions may be as many as those between the 10 and 20.

This last Multitude of Divisions, usually continues to 40, 50, or perhaps farther, and are to be read as those between 20 and 30.

But when the longest come closer together, as generally they do, between 80 and 90, and between 90 and 100, which, on the Scale, is denoted by the Digits 8, 9, 1, there are but Two Orders of Divisions; the greatest still keeping the same Degree, and the other the next lower Degree. And in this one Example, the figured Divisions denote Tens, and the other Units.

But when the first 1 is called 100; then the figured Divisions will be accordingly 200, 300, 400, &c. The mean Divisions, or the next shortest Division, will denote Tens. The shortest between 100 and 200, where the Distance between the Tens is divided only into Five Parts; I say, the shortest here will denote Two Units each of them; and the Middle between these, will denote the single Units; which, if there had been Divisions, as in large Instruments, would have been denoted by those Divisions.

But from 200 to 300, from 300 to 400, and from 400 to 500, the Distances of the Divisions representing Tens, are divided only into two Parts, and consequently, each of these shortest Divisions must represent Five Units; and all other Units, either more or less than Five, must be estimated by the Eye, by supposing each of these Distances cut into
Five

Five Parts. Nevertheless, in larger Instruments, these Divisions may be cut and estimated as before shewn.

Towards the latter End of the Line, the Divisions on these short Lines are so near together, that they scarce admit of Three Orders of Divisions, and consequently (supposing the longer Divisions to denote Hundreds, as in this Example) the Units must be estimated by the Eye.

And in like manner, if the longer or figured Divisions, denote Thousands, the Lines of lesser Length will denote Hundreds, the next Inferior, Tens, &c.

But because, by Inspection, on this Rule it will appear, that more than three Places cannot be distinctly estimated; and, that those are sufficiently exact for all the Uses it is designed for; a farther Division, and Consideration thereon, are omitted.

If the first 1, that is the Beginning of the first Line, denotes a Unit; then the middle 1, or beginning of the second Line, denotes 10, and the last 1 denotes 100.

So, if the first 1 denotes 10; the second 1 denotes 100, and the last 1000.

In like manner, if the first 1 denotes 100; the second denotes 1000, and the last 10000.

And since, when the Value of the first 1 of any Line is known, the Value of the other Figures and Divisions are known also; therefore the latter Line is to be read by the former Directions. And thus are these Three double Lines to be read, as has been shewn, for the former.

But

But the single broken Line, which is on the fixed Part of the Leg of the Rule, is not to be considered in this arbitrary Manner.

For the longer Divisions have affixed to them their Values, which ought to be considered as unvariable, unless in some particular Necessities hereafter to be taken notice of.

From the Beginning of this Line, to the Division mark'd 10, the Distances of the longer Divisions, which are numbred 5, 6, 7, 8, 9, 10, are divided into 10 Parts, by mean Divisions; and therefore, these mean Divisions denote Tenth Parts. And these mean Divisions are each subdivided by one short Line, each denoting therefore Half of one Tenth.

From 10 to the End of the Rule, the Distances between the longer Divisions, are each divided into 10 Parts; and therefore each denotes Units. And the Distances between the Units are each divided into 4 Parts; therefore each denotes one fourth Part of an Unit.

The uppermost of these double Lines is mark'd with the Letter A, the next with B, the third with C; and undermost, which is also called the Girth-Line, with D.

On the Lines A and B, there are placed the small Figures ¹₂, denoting an Index fix'd, tho' the Value of the Divisions should vary.

And, on the Girth-Line, against 12, is generally a Hand or Index for the like Use.

The Two upper Lines are generally used for casting up the Surfaces of Planks.

The Two under ones for Timber.

Having

Having thus far described and explained the reading of this Rule; I shall proceed to shew its Use in measuring Planks and Timber. But shall first shew the Customs used in taking their Dimensions.

And first for Planks; The Buyer hath the Liberty of measuring the Dimensions on that Side of the Plank he judges most advantageous to himself.

Then the Length is measured either with Two Two-foot Rules, or Two-foot Rules, and Five or Ten-foot Rods.

The Length is measured in Feet and Half Feet, and, in some Places, to Quarters of Feet.

Then lay Half this Length from the upper Part, down towards the Butt-end; where, with a Piece of Chalk, make a Mark.

At that Mark, or nearer the Butt-end, if the Buyer think it to his Advantage, is taken the Breadth, in Inches and Half Inches.

If one Side be wainy, the Breadth is taken to the Middle of the Wain.

If both Sides are wainy, one Wain is measured, the other rejected; and either of them as the Buyer thinks fit.

Having thus got the Length and Breadth; call the first long Division on A, and also on B, each an Unit. Then set the Index on B, against the Breadth in Inches on A, and against the Length in Feet on B, will stand the Content in Feet on A.

E X A M P L E.

Let there be a Plank, whose Length is 24 Foot and a Half, and Breadth 17 Inches and a Half; I demand the Content?

Set the Index on B, against 17 Inches and a Half on A, and then against 24 Foot and a Half on B, stands 35 and $\frac{3}{4}$ nearly on A; which is the Measure of the Plank required.

But when the Feet, in Length, on B falls beyond the End of Line A, then call the first 1 on A, a Ten, and then work as before taught.

E X A M P L E.

If a Plank be 45 Foot and a Half long, and 39 Inches broad, What is the Content?

Set the Index on B, against 39 on A, and 45 and a Half on B, will fall beyond the upper End of A.

Therefore set the Index on B, against 39 on A, taking in the first Part of A, because the first 1 on A is counted 10; and then, against 45 and a Half on B, will stand 148 on A, the Content required.

These are all the Varieties which happen in Plank Measure.

But Notice may be taken, That from this Content must be subtracted as much Measure as will ballance all the visible Faults: And this is generally left to the Judgment of the

Two

Two Measurers, and generally done before the Contents are entered in the Accounts, or indeed, before you pass to another Plank.

There are some Differences in the Customs of different Countries, tho', for the most Part, these are the most generally used.

The Customs generally used in taking the Dimensions of Timber, are not much different from those used for Plank.

For the whole Length is first taken in Feet and Halves, then the Middle found and chalk'd, where or nearer the Butt-end, as it is the Buyer's Advantage; the Stick is girth'd with a small Line, which is exactly quartered by twice folding; this Quarter is measured in Inches, Halves, and Quarters. And if the Tree's Bark is not peeled, as always happens in standing Timber; then from the foregoing Girth must be made an Allowance for the Bark, which is usually thus: For Trees girthing one Foot, allow one Inch, and so proportionably for all others. But for Beech, Elm; Ash, and such as are thin bark'd, the Allowance must be a small Matter less.

It is also to be observed, That, a Stick is not called Timber farther than it will hold Half a Foot Girth. Also, that if there be any considerable Arms which hold Half a Foot Girth, they are also called Timber, and measured as such.

C A S E I.

Having thus taken the Length in Feet, &c.
and Quarter Girths in Inches, &c. set 12
(the

(the Index) on the Girth Line, to the Length on C, and then against the Girth on the Girth Line, is the solid Content on C.

EXAMPLE I.

Let a Tree be 24 Foot and a Half long, and its Quarter Girth 17 Inches and one fourth; to find the solid Content:

Set 24 and a Half on C, against the Index on D, the Girth Line; and then against 17 and one fourth on the Girth Line, stands 50 three fourths on C, the solid Content of the Stick.

CASE II.

When, by the foregoing Directions, the Rule is set, and the Girth on the Girth Line is beyond the upper End of C; call the first 1 on C 10; and then work as before.

EXAMPLE II.

Let a Tree be 30 Inches Girth, and 40 Foot and a Half long; to find the Solidity:

If you set 40 and a Half on C, against the Index on D, then 30 on D is beyond the upper End of C.

Therefore, calling the first 1 on C 10, set 40 and a Half on C, to the Index on the Girth Line D; and then against 30 on D, will stand 253 on C, the Solidity required.

CASE

C A S E III.

When the Girths on D fall short of the lower End of C; call the Middle 1 on C, a Unit; and then, all the figured Divisions, below the Middle 1, will be tenth Parts of Feet; then work as above.

E X A M P L E III.

Let a Stick be 3 Foot long, and 6 Inches Girth; to find the solid Content:

Accounting the Middle 1 on C an Unit, set 3 on C, against the Index on D; and then, against 6 on D, stand 7 Tenths and a Half on C; the Solidity required.

E X A M P L E IV.

Let a Stick be seven Foot and a half long; and Girth four Inches: To find the Solidity.

N. B. Tho' this is not what is called Timber, yet since Alders and other Shrubs, used by Turners and others, are often measured, be they never so small; I thought it proper to insert some Examples of this Kind.

In the Three foregoing Cases, the Girths of the Sticks fell on the Girth Line C, without any arbitrary Alteration of the Values affixed to the Divisions; which fixed Values are abundantly sufficient for computing the Solidity of most Sticks usually to be met

I

with,

with, if the single Line C be advantageously broken. For, if a Person designs his Rule for the Measure of Timber only, that is, such as never girths less than Six Inches; then the Girth Line beginning at Six, will run to Sixty Inches: Above which, few Sticks will out-run. But if he designs to measure Alders, Shrubs and small Things, &c. often measured by Turners, Wheelwrights, and other Artificers, using this small Stuff, the best Way is to have the Line C broke, and to begin at 1 and a Half, or 2, and end at 15 or 20, according to the Size of the Stuff they most deal in.

But that the Line, as usual or occasionally broken, may serve for the computing of common Timber, Timber extraordinary large, out-running the Girth Line, and also for Shrubs and small Twigs; it may not be amiss to consider the following Directions and Examples.

And in the first Place, we will enquire into the Use of the Rule in computing the Solidity of such large Sticks, as out-run the affixed Values of the Divisions on the Girth Line.

For which observe, That the Length of a Stick always to be found on the upper End of the Line C, is to be set to the Index; the Divisions on the Girth Line numbered 6, 7, 8, &c. are to be accounted 60, 70, 80, &c. and that, in estimating the Solidity of the Stick, the Divisions on C are to be estimated by 100 times the Value arbitrarily taken thereon by the Length: That is, if the upper

per Part of C be called Units in the Length ; then, in the Solidity, the same upper Part shall be called Hundreds, and the lower Part Tens : In like Manner, if the upper Part of C be called Tens in the Length ; then, in the Solidity, the upper Part shall be called Thousands, and the lower Part Hundreds.

E X A M P L E V.

Let there be a Stick, whose Length is Twenty-five Foot, and Girth Forty-six Inches ; and let Forty-six be above the upper End of the Girth Line : To find the Solidity. .

Then set Twenty-five in the upper Part of C, against the Index on D ; and then against (4 and 6 Tenths on D, which in this Case represents) 46 Inches the Girth, stands 367 Foot on the lower Part of C ; estimated according to the preceding Directions. .

E X A M P L E VI.

Let there be a Stick, whose Length is Four Foot, and Girth Forty-six Inches ; and let Forty-six be above the upper End of the Girth Line : To find the Solidity. .

Set 4 in the upper Part of C, against the Index on D ; and then against the Girth 46, on the lower Part of D (which, in this Case, will be represented by the affixed Value, 4 and 6 Tenths) stands 59 feré on the lower

I 2

Part

Part of C, estimated according to the preceding Directions.

For very small Sticks, whose Girth falls below the beginning of the Girth Line C; observe, that the Length of the Stick always to be found on the lower Part of the Line C, is to be set to the Index; the Divisions on the Girth Line numbered 10, 20, 30, &c. are to be accounted only 1, 2, 3, &c. and that estimating the Solidity of the Stick, the Divisions on C are to be estimated by the 100th Part of the Value arbitrarily taken thereon by the Length; that is, If the lower Part of C be called Units in the Length, then in the Solidity, the same lower Part shall be called Hundredth Parts only; and the upper End Tenth Parts. But if the lower End of C be called Tens in the Length, then, in the Solidity, shall the same lower Part be called Tenth Parts, and the upper End Units.

EXAMPLE VII.

Let a Stick be Fifteen Foot long, and let its Girth be Three Inches; and let Three be below the lower Part of the Girth Line: To find the Solidity.

Set 15 Foot, taken in the lower End of C, to the Index on D; and then against 3 (which, in this Case, will be represented by 30) in the upper Part of D, stands the Solidity 9 Tenths of a Foot, and a Quarter of another Tenth.

EXAM-

E X A M P L E VIII.

Let a Stick be Three Foot long, and let its Girth be Two Inches ; and let Two be below the lower Part of the Girth Line : To find the Solidity.

Set 3 Foot, taken in the lower End of C, to the Index on D ; and then against 2 (which, in this Case, will be represented by 20) in the upper Part of D, stands the Solidity, Eight Hundredth Parts of a solid Foot, and something more.

In those Places where the Custom allows the taking the Length to minute Parts of a Foot ; or when the Length is less than One Foot : Take the Dimensions in Feet, and Decimal Parts of Feet.

Thus much for round Timber ; but when Timber is hewn to that Form which is usually called Square, tho' at the same Time there is most commonly Four Wanes ; the Custom is to take the Length, and find the Middle in the same Manner, and with the same Allowances as were observed in round Timber ; and then, in this Middle, either with a Pair of Callipers, or the Edges of Two Rules applied to the flat Faces, to take the Breadth and Depth of the Stick. Then, to add the Breadth and Depth together, and to use Half their Sum, as you before did the Quarter Girth of a round Stick.

E X A M P L E.

Let a Stick be Twenty-five Foot long, Fourteen Inches broad, and Twelve deep : To find the Solidity according to this customary Method.

Because 14 and 12 give 26, whose Half is 13, set 25 on C against the Index on D ; and then against 13 on D, stands almost 29 Foot and a Half solid.

And tho' this Custom makes the Stick something more than in Fact it is, by adding the Breadth and Depth together, and taking their Half for a Girth ; yet, in a whole Tree, only hewn to a Square, the Difference is so very small, that the Custom may be admitted.

For in this Example it may appear by the Pen, That the Solidity thus is $29 \frac{49}{144}$ Foot ; and the true Solidity, if the Stick be all of the same Bigness, and without Wanes, will be $29 \frac{24}{144}$, differing from the former only $\frac{25}{144}$, or $\frac{1}{6}$ of a Foot solid.

Nevertheless, in Sticks whose Breadth differs very much from the Depth ; the Error is intolerable, and ought not to be admitted.

For, let there be a Stick 25 Foot long, 20 Inches broad, and 6 Inches deep ; then, by the customary Way of adding the Width and Depth together, the Solidity will, as before, be $29 \frac{49}{144}$ Foot ; but the true Solidity will be only $20 \frac{120}{144}$: And so the Error is $8 \frac{73}{144}$ Foot, almost a third Part of the Stick.

For

For the ready Management of such Timbers, there may be placed on the other Leg of the Rule, another Slider ; having the sliding Part and the upper fixed Line, exactly the same as in the former Leg ; but on the other fixed Part, a double Line of the same Radius with the former, but broken and inverted. And as the Lines on the former Leg were distinguished by the Letters A, B, C, D, so the Lines on the latter are noted by the Letters E, F, G, H. And as the Divisions on the Lines A, B, C, were intirely arbitrary, so the Lines E, F, G, are also intirely arbitrary. And on the Line H, which is inverted, and beginning at 1 and a Half, and running on to 150, the Values annexed to the Divisions, may be varied, or remain unvaried. But on the Line E being direct, beginning at 1, and running on to 100, the Values annex'd to the Divisions, may be constant.

The Line H, I call the Depth Line ; the Line G the Breadth Line ; the Line E, I call the Length Line, and F the Content Line.

The Use is so short and so easy, that, in a few Words, and Two or Three Examples, it will be plain.

For, set the Breadth on G, against the Depth on H, and then the Length on E will stand against the solid Content on F.

Let the Stick be that of the last Example ; where the Length was 25 Foot, Breadth 20 Inches, and Depth 6 Inches.

Set the Breadth 20 on G, against 6 on H; and then, against 25 on E, will stand on F almost 21, the Solidity required.

And, to avoid Confusion, remember, That whatsoever is the Value of the Divisions on G, the same shall be the Value of the Divisions on F. That is, if the former Division on G be Units, and the latter Tens, then the former Division on F shall be Units, and the latter Tens. And if the former Divisions on G be Tens, and so the latter Hundreds; then the former on F shall be Tens, and the latter Hundreds.

If the Length on E falls beyond F, call the former Divisions on F, Tens, and the latter Hundreds.

If the Length on E falls short of F, call the former Divisions on E Tenth Parts, and the latter Units.

E X A M P L E.

Let a Stick hewn to unequal square Sides, have its Length 46 Foot, its Breadth 30 Inches, and its Depth 20 Inches, then, when 30 on G is set against 20 on H, 46 on E will fall beyond the Line F; therefore call the former Division on F, Tens; and then set as before, and against 46 on E, will stand $191\frac{1}{2}$ on F, which is the solid Content.

The Shell, or Flitch of Timber is readily cast up by this Rule; for, take the Breadth on the flat Side in the Middle, and one Half the Depth in the Middle, and work with the Length and these, as tho' it were a square Stick,

Stick, and you have the Solidity sufficiently near.

It is indeed true, That this is less than the true Solidity ; but in regard of its Value it is thought enough.

Let there be a Flitch, whose Length is 30 Foot, Breadth 16 Inches, and Depth taken in the Middle 4 Inches. Set 16 upon G to 2 upon H, and against 30 on E, stands on F 6 Foot and two thirds, the Solidity required.

The Sawyers Measure is done by one Setting of this Rule.

For set the Number of Kerfs or Cuts on G, to the Breadth of the Boards on H, and against the Length of the Stick on E, stands on F the Hundreds of Feet Superficial.

E X A M P L E.

Let a Stick, whose Length is 30 Foot, Breadth 22 Inches, and Depth 20 Inches, be so cut, that each Board, with the Waste of the Saw, may be 2 Inches ; that is, if it be cut parallel to the Breadth, we shall have Ten Boards, and so 9 Cuts or Kerfs, and the Breadth of each Board will be 22 Inches.

Set 9 on G against 22 on H, and then against 30 on E, stands 4.12 on F, that is, 4 Hundred and 12 Hundredth Parts of 120, or another Hundred.

Any Plank or Board, whose Value is expressed in Pence *per* Foot, may be cast up by this Rule at one Slip, without knowing the Measure of it.

E X A M-

E X A M P L E.

A Plank of Walnut-tree is sold at 2 s. 9 d. or 33 Pence *per* Foot, its Length is 30 Foot, its Breadth 26 Inches and a Half.

Set the Price in Pence, 33 on G, against 26 and a Half on H, and then against 30 on E, stands 182 on F, and a little more; that is 182 Shillings, or 9 Pounds and 2 Shillings.

It may be observed, That this sliding Rule is sufficiently exact, and very ready for Cubing Stone; provided, that the Two shorter Dimensions are taken in Inches, and the longer in Feet, and Decimal Parts of Feet.

Also, that it may be applied to the Cubing in Feet, any Solid in Form of a Parallelepipedon, whose Content doth not consist of more than 3 Places.

And if a Line be properly broken, and put on instead of H, it might be applied to Digging, &c.

Or if the Line H did slide as well as G, it might be applied to the measuring of all Sorts of Parallelepipedons, by one Setting of the Rule, whether the Answer be required in Feet, or Yards, or Rods, &c.

It remains to say something concerning the Estimation of the Measure of Timber standing.

And,

And, First, We may observe, That, if we can get the Dimensions, the Manner of computing, after an Allowance for Bark, is that already laid down.

But since we cannot always get all the Dimensions, we must take those we can get at, and estimate the rest.

And, first, we may observe, That the Dimensions in a tapering Stick, which runs beyond Timber, may be had thus: Girth the Stick Breast-high, to an 8th Part of this Girth, add Three Inches; and the Sum lessened by Allowance for Bark, will give the Girth in the Middle. And for the Length, measure from the Ground so high as the Tree runs Timber, and then work as before.

E X A M P L E.

Let the Girth Breast high, be 6 Foot, and Length 40 Foot; then, because the 8th Part of 6 Foot is 9 Inches, to this add 3 Inches, and the Sum is 12; from this deduct an Inch for Bark, and there will be left 11 Inches; which, with the Length 40 Foot, gives 33 Foot and a Half for the solid Content.

When the Taper Stick doth not out-run Timber at the Top, the whole Girth, at Top, shall be added to the whole Girth Breast high; and an 8th Part of this Sum shall be the Girth in the Middle; which, after an Allowance for Bark, shall be the Girth to be used.

The

The usual Way of estimating the Height of the Tree, is, by applying to it a Ten or Twenty Foot Rod, and standing at a convenient Distance, and comparing the Rod with the Tree.

But the most certain Method is by the *Theodolite*, as now improved, thus : Measure from the Tree with a Ten-foot Rod 100 Foot, level the *Theodolite*, and direct the Telescope to the Top of the Tree ; and then shall the Telescope cut on the Vertical Arch (if the Ground, from the Tree to the Instrument, be nearly upon a Level) a certain Number of Feet ; to which, if you add the Height of the Telescope, you will have the Height of the Tree.

But if the Ground, from the Tree to the Instrument, be not quite Level, then direct the Telescope to the Top of the Tree, and note the Feet cut by the Telescope ; and then direct the Telescope to the Bottom of the Tree, and note the Feet there cut.

And if one of these Numbers of Feet be above the Level, and the other below, then their Sum is the Height of the Tree ; but if both are above, or both below, then the lesser taken from the greater, will give the Height of the Tree, without any other Calculation.

When the Ground, from the Tree to the Instrument, is very steep, take, with your Off-set Staff, or Five-foot Rod, the Height of the Instrument above the Ground, and at the same Height on the Tree above the Ground the Tree stands on, make a Mark.
Direct

Direct the Telescope to this Mark, and it will cut on the Vertical Arch among the Divisions of Reduction, which shew the Difference between the Hypothenuſe and Baſe, a Number of Feet which added to 100, will give the proper Diſtance to plant the Inſtrument from the Tree; or, which is the ſame Thing, it ſhall give a Length on the Aſcent, which answers to 100 Foot meaſured Horizontally, very near.

The Inſtrument being planted at this Diſtance, work as before, and you will have the Height of the Tree correct.

Having mentioned this Vertical Arch, and its Uſe in taking Heights, I will now proceed to ſhew its farther Uſes in ſurveying Land.

If, in coming up an Aſcent, or going down a Deſcent, as ſoon as the Inſtrument is ſet for obſerving the Angle; you look on the Vertical Arch among the Diviſions of Reduction, you will find how many Links, in every Chain's Length, this Hypothenuſal Line is to be ſhortened, in order to get the Horizontal Line, which ought to be laid down in your Plan, and muſt be entered in your Book.

And theſe Diviſions of Reduction are concentric with the Diviſions of Altitude and De-preſſion, and alſo with the Diviſions of Degrees.

Laſtly, If the Diſtance from the Tree to the Inſtrument be confined; then multiply the Horizontal Diſtance in Feet, by the Feet given by the Inſtrument, and from the Product, towards the Right-hand, cut off Two Figures, and thoſe to the Left, will be the Height of the Tree in Feet.

S E C T.



IX.

*The Use of the Theodolite, in
drawing the Perspective Ap-
pearance of any Building with-
out Measuring one single Line.*



HIS will admit of some Variety ; for either the Picture is supposed to be parallel to one of the Fronts of the Module or Building ; or else oblique to both ; and then is either in a Position assigned, or in a Position taken at Pleasure.

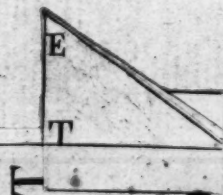
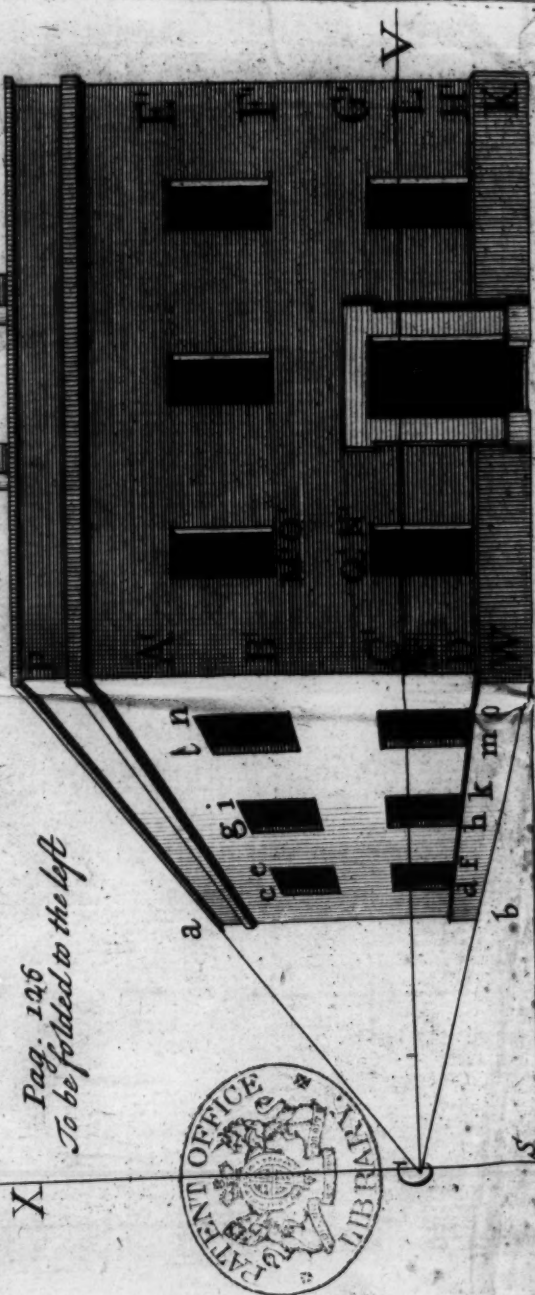
First, Suppose the Picture parallel to one of the Fronts, then plant the Instrument and a Staff at any equal Distances from the Front, suppose 5, 10, or 15 Foot ; then direct the Telescope to the Staff, and the Needle will point out the Bearing of that Front : To this add or subtract 90 Degrees, you will have the directing Number ; that is, the Bearing of the Line perpendicular to the Front.

Now plant your Instrument at the Place, whence the original Building is to be viewed.

Bring

Fig. 21

*Page 126
To be folded to the left*



Bring the Index to the Beginning of the Divisions, and turn the whole Instrument about, till the Needle points at the directing Number; and then screw it fast. Bring the Telescope to the Beginning Divisions in the Vertical Arch, and level the whole Instrument: So will the Instrument be duly seated and rectified for Observation.

In order to get easily a due Knowledge of Perspective in general, and particularly of the Use of this Instrument in Drawing, turn to Figure 21, and raise up the Draught P K perpendicular to the Plane of the Leaf upon the Line W K, and lift up the Plate A Y W, till it is perpendicular to both the Plan of the Leaf, and also to the Draught P K; then raise the Draught A B W, till it coincides with A Y W, and consequently will be perpendicular to the Plane of the Leaf, and also to the Draught P K; so will the Two Draughts A W, P K, be the Two Fronts of the Module, represented to the Eye. Lift up the Draught a V, till it is perpendicular to the Plane of the Leaf, and it will be the Picture designed to be drawn; and it will coincide with P K, the Front of the Module. T is the Point on the Ground whence the Building is to be seen. Lift up E T, till the Point E is perpendicularly over the Point T: And E is the Eye of the Spectator, or the Centre of the Telescope. Now if you conceive strait Lines drawn from the Eye at E, to the several Points A, B, C, D, &c. in the Module, they will meet the Picture in the Points a, b, c, d, &c. which are therefore
the

the true Appearances of those original Points A, B, C, D, and a Line drawn from a to b, will be the true Appearance of AB; and so of all other Lines: For the Rays of Light come to the Eye from the Picture in the very self-same Direction that they would have come from the original Module. Thus much by Way of Introduction.

Now, in order to draw the Picture: Assign on your drawing Board any Point C, at Pleasure, for the Centre of the Picture; and draw C V the horizontal Line, and perpendicular to it, the Vertical Line C X; from these Two Lines, all the Parts of the Building are to be laid down by their apparent Distances from them.

N.B. By the Centre of the Picture, I mean that Point, whence, a Line drawn to the Eye is perpendicular to the Plane of the Picture. The Horizontal Line is that which passes thro' the Centre, and is parallel to the Horizon; and therefore is the common Intersection of the Picture, with the Plane of the Ocular Horizon.

The principal Line in these Draughts is, that Coin, or that Angle which is common to both, the Picture and the Module; and consequently every where proportional to the Building it self; And is the first Line to be laid down and divided; which may be done thus: Let the Example be as in the preceding Scheme.

Direct

Direct the Telescope to the Point P in the Building, and you will find the Index on the Horizontal Plate of the Instrument cut 32 Foot and a Half, and on the Vertical one 25 Foot; lay the latter above the Horizontal Line CV, and perpendicular to it, from C to X; and the former from C to x. Then, by Help of the Square, draw x P, X P perpendicular to CV, CS, whence the perspective Appearance of the Point P is found.

In like Manner, may be found the perspective Appearance of any Point whatsoever, whether it be coincident to both the Module and Picture or not.

Depress the Telescope to W, in the Building, and (in this Example) it will cut on the Vertical Arch 9 Foot; which, because you look downwards, lay from x downwards to W in the Picture, and so you have the true Appearance of W. And consequently, if you draw P W in the Picture, you have the true Appearance of the Line P W in the Building.

If you elevate the Telescope to A', in the Building, it will cut on the Vertical Arch 15 Foot; which laid from x to A' in the Picture upwards, because the Point is above the Horizontal Line CV, will give the Representative of that Point in the Picture. And so every of the Points B', C', D', &c. may be laid down in the Picture.

Direct the Telescope to K' in the Building, and you will find on the Horizontal Arch, that the Index cuts 69 Foot and a

K
Half;

Half; which laid from C to L', gives in the Picture, the Representation of the Point L'.

Thro' L', draw E' L' K' perpendicular to C V, and A' E', B' F', C' G', &c. parallel to it, thro' the Points A' B' C', &c. and so the Coins E K, and the Tops and Bottoms of the Doors and Windows may be limited in respect of their Heights.

Direct the Telescope to Q, and it will cut on the Horizontal Arch 38 Foot and a Half; which lay from C to Q', and it will determine the Appearance of Q'. In like Manner may N'; and the Jaumbs of the Windows Q' N', M' O', be laid down. As also the other Windows, Doors, &c.

For the returned Front a W, draw P C, W C, A' C, B C, C' C, D' C, &c. and they will limit the Heights of the Parapets, Facia's, Windows, &c.

Direct the Telescope to b, d, f, h, &c. and it will cut on the Horizontal Plate 16 Foot, 17 Foot and a Half, 19 Foot and one Third, &c. -----, which laid from the Vertical Line X S, will give the Breadths, representing the Piers and Windows.

The same may be done for the Chimneys and their Returns; or for any other Lines, Breaks, &c. And so the several Parts of the perspective Appearance of a Building may be drawn without Measuring.

That this Compendium of Perspective may be compleat, it may not be amiss to lay down the necessary *Theorems* in the most general Manner possible; and herein I shall use those Terms which Dr. Brook Taylor hath thought
fit

fit to mention, they being more comprehensive than such as are used by the other Writers on this Subject.

Theor. I. All Lines originally (or in the Module) parallel to one another, and to the Picture; will be represented by Parallels on the Picture.

Theor. II. All Lines parallel in the Module or Building which are perpendicular to the Picture, will, if continued, run to the Centre of the Picture. Tho' these Parallels be or be not all in the same Plane.

Theor. III. All Lines in the Module or Building, perpendicular to the Plane of the Horizon will be in the Picture, perpendicular to the Horizontal Line. And these Three *Theorems* are sufficiently visible in the preceding Example.

Theor. IV. All Lines in the Module or Building, parallel to one another, and to the Plane of the Horizon, but oblique to the Picture (as in the following Example) will meet in some one Point in the Horizontal Line CV. This Point is (by Dr. Taylor) called the vanishing Point of these Parallels, and is by him thus found:

From T, the Point representing the Place from whence the Building is to be viewed, draw a Line parallel to the Parallels; and where it meets the Ground-Line SR, raise a

Perpendicular R Y, and you have the vanishing Point required.

Theor. V. All Lines which are parallel to one another, but oblique to the Picture, and not parallel to the Plane of the Horizon, will be represented by Lines meeting in a vanishing Point, found by the Intersection of the Picture, and a Line drawn from the Eye parallel to those Parallels. But this vanishing Point will not be in the Horizontal Line, but either above it or below it.

Theor. VI. The Shadows of all parallel Lines made by the Intersection of the Sun's Rays, will, on the Ground, be parallel; and consequently in the Picture, either be parallel, as in *Theorem I.* or else meet at a Point in the Horizontal Line, as in *Theorem II.*

Now, as in the former Example, the Centre of the Picture being determined, the Parallels which were perpendicular to it, and also parallel to the Plane of the Horizon, were, by the Help thereof, easily drawn; so in this Example following, since the vanishing Points are of no less Use to draw all Parallels, I shall shew one general Law, without any Exceptions, for this Purpose; not after the Manner of *Dr. Taylor*, but by this *Theodolite*, which, as well as all Sorts of Mathematical Instruments, according to the latest Improvements, is made by *THO. HEATH* at the *Hercules and Globe*, next Door to the *Fountain-Tavern* in the *Strand*.

Let

Let the Example be that of *Fig. 22.* where, as before, raise the Draughts PQ , AWY , ABW ; and you have the Module represented to the Eye (AWY coinciding with ABW) raise a Q perpendicular to the Plane of the Leaf; and it is the Plane of the Picture designed to be drawn; but it is oblique to each Front of the Module: And the Coin PW is the only Part of the Module or Building, which coincides with the Picture. Raise up TE , as in the former Example: And E represents the Eye beholding the Building or Picture. Plant the Instrument and a Staff in the Line SW , which is the Ground-Line of the Picture, or else at equal Distances from it, that is, parallel to it. And find, as in the foregoing Example, the directing Number.

Plant the Instrument at your designed Station T ; and rectify it as in the preceding Example. Assume the Centre C , on the drawing Board, draw CV , CX , as before.

Then lay down PW , and its several Divisions A' , B' , &c. and the Two Points a , b , as in the former Example. Draw Pa , and Wb , and produce them till they meet: So shall their Intersection V be the vanishing Point sought.

Use this Point V as you did the Centre of the Picture in the preceding Example; and then go on to draw the Front aW as before.

In like Manner find the vanishing Point Y ; and proceed to draw the Front PQ .

As to the Position of the Picture, some Persons will have it parallel to a Front, others

parallel to the Diagonal of the Plane; others chuse rather that Position to which a Line drawn from the Eye to the common Coin P W may be perpendicular to the Plane of the Picture.

And in this latter, there is no Occasion for the directing Number, or the Bearing of any Front; For take T the Station at Pleasure; bring the Index to the Beginning of the Degrees on the Horizontal Plate, and turn the whole Instrument about till you see thro' the Telescope the Coin P W, and screw it fast, and level it; and proceed in all respects as in the last Example.



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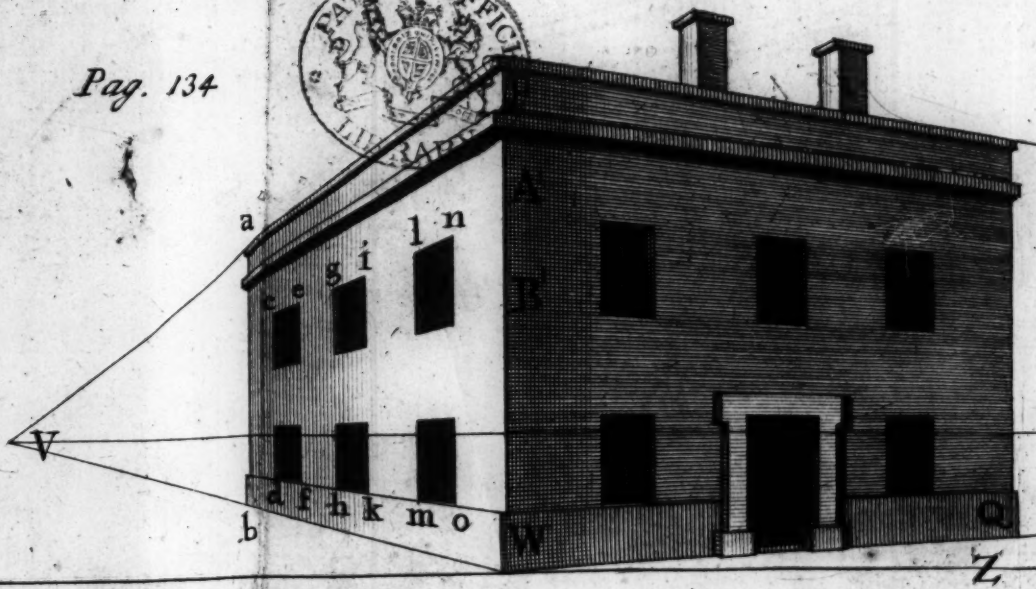


Fig. 22

X

C

S

Y

R





 S E C T. X.

*Of Surveying of Shoals and Sands,
by Help of the New Theodolite.*



HERE are Three Methods where-
by this may be performed ; for the
Observations may be made either
on the Water or on the Land.
Those made on the Water are of Two Kinds,
One by the Log-line and Compass (as in plain
Sailing) measuring the Course and Distance
round the Sand ; and then to be plotted as a
large Wood, or any Enclosure taken by the
Circumferentor.

This Method I omit for Two Reasons ;
First, because it is to be deduced from the
Writers of Navigation ; and, Secondly, be-
cause the Distances thus measured are liable
to the Errors of Currents, which generally
attend Shoals or Sands, which are always
near to the Shore.

The Second Method, where there are no
Distances to be measured on the Water, tho'
still there is one Inconvenience, common also

to the former, because the Bearings or Observations are to be taken on that unstable Element, (an Error scarce mentioned by our practical Artists) I shall briefly hint at ; and so rather chuse a Third, which is liable to neither of these Imperfections.

Let (in *Fig. 20.*) a Boat be manned out with a Signal Flag, a Log and Line, Lead and Line, and to observe the Bearings of any Land-Mark, a Compass with Sights :

Take Two or more Places, as A, B, C, on the Shore, from whence the Boat may be seen on the several Parts of this Shoal.

One of the Boat's Crew is to sound till he finds himself on the Edge of the Sand, by the Depth of Water, and then to come to an anchor ; which he is to signify to two Persons on the Shore, at B and C, by his Signal. And then from those known Land-Marks, B and C, the Observers are to take the Bearings of the Boat, and to register their Observations ; which, when done, they are to signify to the Crew by waving a Flag, or by some other Signal.

And in the mean Time, to prevent Mistakes, let the Crew, take the Bearings of each of these Land-Marks : Then weigh anchor, which suppose at D.

Then by Sounding, proceed to E, and make like Observations. And so at E, F, G, &c. till you have surrounded your Sand.

And if in this Process, you are about to lose the Sight of one of your Land-Marks, suppose C, let your Assistant at C, who, at that Time, will also be about to lose the
Sight

Sight of the Boat by Signals (before-hand agreed on) remove to some other Object before-hand agreed on, suppose to H; and then to proceed as before.

Lastly, If the Sand runs so far out to Sea, that the Object cannot be seen by the Boat, nor the Boat by the Observer on Shore; there may be Rockets fired by the Boat's Crew, and also the Observers on Shore in the Night, by which those Bearings may be taken almost at as great a Distance as the Light can be seen. For supposing they rise but one half Mile, and one quarter of a Mile above the apparent Horizon, its Stay will be about 9 Seconds, and its Distance for this quarter of a Mile will be visible about 44 Miles.

But Rockets rise much higher, and then the Distances are much greater, whereby they are visible.

Or two Boats may lie at Anchor instead of the Land-Marks, and then you may work as before.

Now, Since the Land-Marks B and C are fixed, their Position may be laid down in the Draught, as in common Surveying, by plotting the Distance between B and C. And then, by plotting the Line B D, and the Line D C, according to their Position, their common Interfection, will give the Point D. And in like Manner, E, F, G, &c. may be plotted; and so the Shoal: And this from the Bearings taken at B and C.

If this be a standing Lake, environed by Bogs, not to be walked on; the Observations at D, E, F, &c. by taking their Opposites,
may

may suffice to plot the same from the Land-Marks A, B, C, &c. as well as those taken on the Land ; or, indeed, by the Course and Distance, as in Navigation, if the Water be smooth and without a Current.

In Sea-Shoals, it is convenient to note at each Observation the Depth of Water found by the Lead, and the Drift and setting of the Current by the Log and Compass, while the Boat is at an Anchor, which may be done with Ease and Expedition enough. For while the Boat rides at an Anchor, her Stern points out the Setting of the Current, and the Log and Glass will measure its Drift.

And these ought to be noted on the Draught, which may be thus :

The Currents may be shewn, by drawing a Dart pointing out its Setting, and its Drift by the Roman Capital Letters, and the Depth of Water by the small Figures.

All Nocturnal Observations ought to be several Times repeated,



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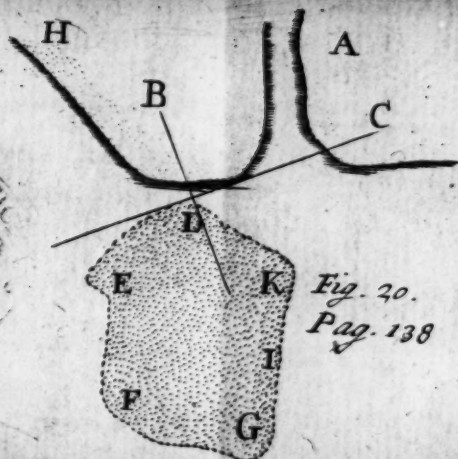
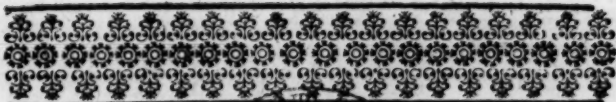


Fig. 20.
Pag. 138



 Of COLOURS.



T is not worth while to speak of the Preparation of Colours, because they may be had ready prepared, at almost every Colour-Shop and Fan-Painter's, &c. Nor to mention but as many as are necessary and most fit for the Surveyor. Those, I judge the best, which are most transparent, and most easily transportable.

And for Portability, I think Liquids improper; therefore would rather chuse those Colours, which, before tempered, are dry; whether in Powder, or in Lumps: And such as require no other Liquid to mix with them (than what is to be had every where) viz. fair Water.

For *Gum Water*, with which many Colours are mixed, is made by barely steeping *Gum Arabick* in fair Water.

Carmine, a Powder, mixed with *Gum Water*, is a beautiful Red; may be shaded with some of the same, mix'd stronger; or with any reddish Brown, or any sadder Red.

Ultra-

Ultramarine, a Powder, mixed with *Gum Water*, is a most valuable Blue, fit to shew Ponds, Lakes, Rivers, &c. it may be shaded with *Indigo Corns* ground with fair Water on a white Tyle, by the Pressure of a Knife's Point, and then mix'd with *Gum Water*.

Red Chalk, a Lump, sometimes called *French Chalk*, ground by rubbing it on a Tyle with fair Water, and afterwards with *Gum Water*, slightly laid on, is proper to represent Roads and Pits; and is shaded by itself more strongly mix'd.

Sap green, steep'd in Water, of itself a good Green to colour Trees.

Verdegreece, in Lumps, dissolved in Vinegar, or in Water, makes a greenish Blue, or Sea-Colour, very transparent.

Gumbooge, in Lumps, steep'd in fair Water, produces a beautiful and transparent Yellow.

Yellow Berries, steep'd in fair Water, a Yellow.

Verdegreece dissolved, mixed with *Gumbooge*, or yellow Berries, in different Proportions, produces different Greens, inclining either to the Blue or Yellow, according to the Quantities of either used.

All Colours are shaded by others of the same Sort, but more sad.

I shall not trifle, in telling how these Colours may be compounded, or laid on, they being to be known by Experience much better than by many Words. Nevertheless, in my Judgment, a Draught looks best when the Stains are only visible.

S E C T.



S E C T. XII.

*Of Water-Levelling, or the Con-
ducting of Water.*



THE first Thing necessary to this Purpose, is the adjusting of the Level, which may be performed several Ways: This that follows is very easy and natural.

Chuse some Ground which is not above 4 or 5 Foot out of the Level, for the Distance of 8 or 10 Chains Length, and suppose it be AB (Fig. 17.) and find the Middle between A and B, which suppose to be C; plant the Instrument at C; direct the Tube to a Station Staff, held up at A, and elevate or deprefs the Tube, till the Bubble is exactly in the Middle of the Divisions; then by Signals direct your Assistant at A, to raise or deprefs the Vane, sliding on the Station Staff, till the Horizontal Hair in the Glass, cuts the Middle of that Vane; then see how many Feet, Inches, and Parts, are cut by the upper Part of the Vane, which suppose to be 3 Foot 4 Inches and 6 Tenths.

In like manner direct to the other Staff at B, and suppose the upper Edge of that Vane to cut at the Height of 6 Foot 5 Inches and 2 Tenths; then will these two Vanes be on a Level.

From 6 Foot 5.2 Inches subtract 3 Foot 4.6 Inches, and reserve the Remainder 3 Foot 0.6 Inches.

Now, remove the Instrument as close to the higher Station Staff as you can; so that the Middle of the Telescope may almost touch it. Then bring the Telescope as near to a Level as the Judgment of the Eye will direct.

Measure the Feet, Inches, and Parts, that are even with the Top, and also with the Bottom: Suppose them to be 4 Foot 10.5 Inches, and 5 Foot 0.3 Inches; then half the Sum of these Heights 4 Foot 11.4 Inches, is the Height of the Centre of the Glass; and to this add half the Breadth of the Vane, which suppose to be 1 Inch and 5 Tenths, and to the Sum 5 Foot 0.9 Inches, add the preceding Remainder 3 Foot 0.6 Inches; then let the Person at B move his Vane, till the upper Edge cut 8 Foot 1.5 Inches, the Sum of the preceding Numbers.

Now, so elevate or depress the Hair or the Bubble, till the Hair cut the Middle of the Vane at B, and at the same Time the Bubble stands in the Middle of the Divisions; and then will the Instrument be duly adjusted.

If

If you have a Mind to be curious, repeat the Operation ; but when you place the Instrument at C, turn the Tube at right Angles to the Line AB, and there set it level ; then proceed with the Repetition of the Work. Only observe to cross-level it in this Adjustment, and in all future Uses whatsoever.

* Or the Level may be adjusted thus : As before, first plant the Instrument in the Middle between A and B (Fig. 18.) and observe the Heights on the Station Staves, which suppose to be as above ; and consequently their Difference, as before, is 3 Foot 0.6 Inches. Now measure from C towards the highest Ground A, some Distance that comes almost to A ; suppose 4 Chains to D, then will DB be 9 Chains, and DA be 1 Chain : Then plant the Instrument at D, direct the Telescope to A, and, setting the Bubble to the Middle of the Division, direct your Assistant to move the Vane, till the Hair cuts the Middle of it ; and note down the Feet, Inches, and Parts cut by the upper Edge of the Vane ; which suppose to 3 Foot 8.4 Inches : To this add the Difference 3 Foot 0.6 Inches, and the Sum 6 Foot 9 Inches reserve.

Now direct the Telescope to the Staff at B, level it, and direct your Assistant to move the Vane, till the Hair cuts the Middle of the Vane ; and then, if the upper Edge of the Vane cuts the foregoing Sum 6 Foot 9 Inches, the Hair and Bubble are truly adjusted. But if not, say, As BD
wanting

wanting A D, is to the Difference between the Numbers cut by the upper Edge of the Vane, and the Number 6 Foot 9 Inches; so is the Distance A D to a Number, which added to that cut by the Vane, when less than 6 Foot 9, and subtracted from the Number cut by the Vane, when it is greater than 6 Foot 9, will give a Number, to which let the Assistant fix the Vane; then, so elevate or depress the Hair or the Bubble, till the Hair cuts the Middle of the Vane at B, and the Bubble stands in the Middle of the Divisions; for then the Level will be adjusted. The Operation may be again repeated, and at every Station cross-levell'd, which will confirm the former Adjustment.

After the Instrument is duly adjusted, you may proceed to use it. Let the Example be this annexed, (Fig. 19.) where A every where represents the Level, and B the Station Staves; and suppose the Rout be made from a to e; first plant the Instrument between the Station Staves a and b: At A direct the Level to aB, bring the Bubble to the Middle of the Divisions, and instruct your Assistant so to place the Vane, that the Hair in the Telescope cuts the Middle of the Vane; then in a Book divided into two Columns, the one intituled *Back Sight*, the other *Fore Sight*, enter the Feet, Inches, and Parts cut by the upper Edge of the Vane at aB, in the Column intituled *Back Sight*.

Then look towards the other Staff bB, bring the Bubble to the Middle of the Divisions,

sions, and direct your Assistant to place the Vane so, that the Hair cuts the Middle of the Vane; then enter the Feet, Inches, and Parts cut by the upper Edge of the Vane, in the Column of *Fore Sights*.

Now, plant the Instrument at A², still keeping the Staff B b exactly in the same Place, and carry the Staff a B forwards to the Place c B; now look back to the Staff b B, and enter the Numbers cut by the Vane there, under the Title *Back Sight*; then look forwards to c B, and enter the Observation under the Title *Fore Sight*. Do the like when the Instrument is planted at A³, A⁴, &c. always taking Care to keep the Staff in the same Place when you look'd at it for a *Fore Sight*, till you have also taken with it a *Back Sight*.

Having finished your Level, add up the Column of *Back Sights* into one Sum, and the Column of *Fore Sights* also into one Sum; and the Difference between these Sums is the Ascent or Descent required. And if the Sum of the *Fore Sights* is greater than the Sum of the *Back Sights*, then e is lower than a; but if the Sum of the *Fore Sights* is less than the Sum of the *Back Sights*, e is higher than a. For Example-sake, let the Numbers be as in the following Table.

L *Back*

<i>Back Sights.</i>			<i>Fore Sights.</i>		
F.	I.	P.	F.	I.	P.
3 . 7	L	5	6 . 4	L	5
4 . 6	L	8	8 . 3	L	2
6 . 0	L	2	5 . 4	L	7
9 . 5	L	0	8 . 7	L	8
1 . 0	L	7	9 . 4	L	8
24 . 8	L	2	38 . 1	L	0
			24 . 8	L	2
			13 . 4	L	8

Hence the Descent is 13 . 4 L 8

Now follow some Observations well worth Notice.

I. If the Sum of the Distance in taking the *Back Sights*, is equal to the Sum of the Distances in taking the *Fore Sights*, all the Minute Errors of the Instrument will mutually ballance and destroy each other.

II. And if the Distances thus taken are short, the Curvature of the Earth may be rejected. For, if the Distance from the Instrument be every where about 100 Yards, all the Curvatures in a Mile's Work will be less than half an Inch.

III. If

Fig. 19



Fig. 18

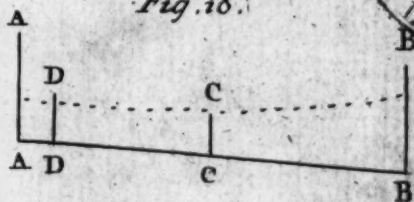
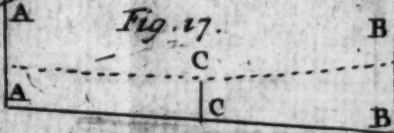


Fig. 17



III. If the Distances from the Instrument to the hindermost Staff, be every where equal to the Distance from the Instrument to the corresponding Staff; the Curvature of the Earth, and the Minute Errors of the Instrument will both be destroyed.

IV. If the Distances of the Instrument from the Staves, be very unequal and very long, the Curvatures must be accounted for, and the Distances, in order thereto, must be measured, either by Pacing, by a Chain, or a Wheel.

V. For the more ready allowing for the Curvature, you may observe, That the Curvature for one Mile, taken at one Observation, is extremely near to 8 Inches. And at all other Distances, it is as the Square of 1 Mile is to 8 Inches, so is the Square of any other Distance to the Allowance for the Curvature; and that this Curvature is always to be subtracted from the Numbers taken off the Station Staff: Or if the Distance be less than a Mile, and taken by the Four Pole Chain; square the Chains, cut off 2 Places to the Right-Hand, and divide those to the Left by 8, and the Quotient shews the Inches and Parts of Inches to be allowed for the Curvature. Suppose the Distance be 30 Chains; then the Square of 30, that is, 900, when 2 Places are cut off, gives 900, or 9, which divided by 8, gives 1 Inch and 125 Thousandth Parts of an Inch,

VI. If these Distances were taken by Pacing, accounting 25 to the Chain, the Curvature may be found thus; Square the Paces, and double it, cut off 6 Places to the Left-Hand, and those to the Right are the Inches of Curvature: So, if the Paces were 900, then from 810000 multiplied by 2, that is, 1620000, cut off 6 Figures, and you have 1.62, the Curvature to be allowed. To save the Trouble of continual Calculations you may use the following Table.

Distances in Chains,	Allowances, in Inches, and Parts.
5	— 0.03
10	— 0.12
15	— 0.23
20	— 0.50
25	— 0.78
30	— 1.12
35	— 1.53
40	— 2.00
45	— 2.28
50	— 3.12
55	— 3.78
60	— 4.50
65	— 5.31
70	— 6.12
75	— 7.03
80	— 8.00
85	— 9.03
90	— 10.12
95	— 11.28
100	— 12.50

VII. There-

66
80
15200
1760

VII. Therefore it appears, That the best Method to take a Level, is to measure the several Distances from the Instrument to the Back and Forward Station Staffs; and enter them in the Field Book, according to the Titles of their several Columns, as here below; and before you balance the whole Levels to make the Sum of the Distances of the *Fore Sights*, equal to the Sum of the Distances of the *Back Sights*; and to account for the Curvature of the Earth, which may be done at Home, when you are about to sum up the Heights.

[illegible]

L 3

Lastly,

Lastly, Though hitherto we have considered the Level with one Telescope only, the same Observations may be applied to a Level with a double Telescope; and I would advise those who use the double Telescope, at every Station to turn that End of the Telescope towards the Spring, which, before was the contrary Way.



S E C T.



S E C



*The Use of the Universal Dial,
and the Variation of the Compass.*



T hath been supposed, That a Needle, playing freely, which hath had a strong Touch from the Loadstone, points exactly North and South. But by numberless Experiments it hath been proved, That the Needle doth not point exactly North and South, in any Places of the World, but such as lie on one particular Line, which is therefore called, *The Line of no Variation*; And that this Line changes its Situation by a slow Motion, from East to West. It now passes from the Westward of the *Cape of Good Hope* to the *West-Indies*. And the Variation of the Needle in all other Places is known constantly to alter by a slow Change. In *England* that End of the Needle which hath been supposed to point full North, deviates from it now about 14 Degrees to the Westward; and is still, and also will for many Years continue to increase, even till it arrive at its

L 4

Maximum;

Maximum; and then will decrease till it vanishes, and then change to the Eastward, as it formerly was; and by an oscillatory Change will so continue to alter.

This Variation of the Needle would no ways hinder the Exactness of the Survey, if it was constant; nor is the Alteration of the Variation capable of making any sensible Error in a Survey that is performed in a Space of Time not exceeding four or five Years.

But if the Quantity of the Variation be not known, and consequently not allowed for, the North Point of the Compass, which the Surveyor draws on his Map, will err as much as that Variation is. It is therefore convenient in all Places to find it; and this may be done several Ways: But by none more readily, more easily, or more exactly, than by the universal Dial, as made now by Mr. HEATH, the Instrument-Maker mentioned before.

This Dial's Pedestal consists of a Box and Needle, which is placed truly Horizontal by the Help of Cross-Levels therein, and may be turned round in that Position. The Ring representing the Meridian, is divided into Degrees, and hath a Provision made to elevate it to any Latitude North or South. The Ring representing the Equinoctial, is divided into Hours, Halves, Quarters, or Minutes, according to its Largeness. The Bridge hath on one Side the Days of the Month, and on the other the Sun's Place and Declination.

In

In Time of Observation; the Latitude of the Place on the Meridian must be brought to the Index; the Slider on the Bridge must be brought to either the Day of the Month, the Sun's Declination, or the Sun's Place, and then it will accordingly shew the other Two. The Equinoctial Circle must be thrust out of the Meridian, till it is at right Angles to it. Then bring the Beginning of the Degrees on the Horizontal Part to the Index there. Turn the Whole about upon the three Feet, till the Sun shines equally on both Faces of the Plane of the Meridian, and level it. And so shall the Dial be duly rectified for Observation.

Now keeping the three Feet in the same Place, turn the Dial about, till the Spot of Light passing thro' the Hole in the Slider, falls on the Circle which is divided into Hours, &c. in the Middle of the Inside of that Ring which represents the Equinoctial, among the Morning Hours, if before Noon, and among the Evening Hours, if after Noon; then will the Dial shew these following very useful and pleasant Problems.

1. The Spot of Light points out exactly the Hour of the Day.
 2. The Circle representing the Meridian, lies exactly in the Plane of the Celestial Meridian; and so a Thread stretch'd over either Face of it, draws a true Meridian Line.
 3. The Middle of the Bridge points exactly to the true Poles.
 4. The Needle in the Box shews the Variation by its End's Distance from the Beginning of the Degrees there mark'd;
- + and

and is Westward, if the North End of the Needle be to the Left-Hand of the Beginning of those Degrees, but Eastward when to the Right. 5. The Index on the Horizon, points out the Sun's *Azimuth*. 6. Turn the Meridian about the Plane of the Horizon, till the Sun shines equally on both its Faces as at first, the three Feet still standing in the same Place, and elevate or depress the Sights, till the Spot of Light coming thro' the uppermost falls exactly in the little Hole in the undermost: then the Index in the *Zenith*, points to the Sun's Altitude, among the Divisions of the Meridian.

If a strait Ruler, whose Sides are parallel, be applied to a Wall, on which a Vertical Dial is designed to be drawn, and the two Feet of the Dial mark'd A, A, be applied to the other Edge of the Ruler; and the Dial be rectified to the Latitude of the Place, and the Day of the Month, and levelled, and the upper Part of the Instrument be turn'd about till the Spot of Light fall as before; then the Index on the Horizon will give the Situation of that Wall, usually call'd by Diallers, The Declination of the Plane. Or, apply the Legs A, A, to the Ruler, and turn the upper Part about, till the North End of the Needle points at the Variation, and then, as before, you may see the Situation.

This curious Instrument is of great Use for the Regulation of Clocks and Watches, by the Help of the apparent Time observed by it (as taught above) and the Equation
of

of Time engraved on the Horizontal Part of the Pedestal.

It is also a very ready Instrument for Seating an Horizontal Dial duly : For after the apparent Time is found by it, and the Horizontal Dial so seated, that it may be turned about, and still be parallel to the Horizon ; turn it so about, that the Sun shining thereon, it shews the same Hour that the universal Dial shews, and then it is truly placed, and may be there fixed to the Pedestal.

And because the Latitude of the Place where the Instrument is used, must be known ; there is engraved on the Backside of the Meridian, or the Underside of the Pedestal, the Latitudes of the Cities, and most remarkable Towns in *England*, and the other Parts of *Europe*.

But if any Gentleman pleases to communicate to the Workman, the Latitudes of his Country Seats, they may be particularly laid down on it.

Or if any Gentleman about to travel, is pleased to communicate the Tour he designs to take, he may have a Catalogue of the Towns in his Way, and their Latitudes, from Mr. *Heath*, with the Instrument, in order to ease him of the Trouble of Searching Maps, Globes, or Geographical Books.

He that hath not this Dial, may find the Variation by the *Theodolite*, thus : Take the Bearing of the Sun exactly at 12 at Noon, and the North-End of the Needle gives the Variation.

Or,
+

Or, take the Bearing of the Sun, either Rising or Setting ; and then, by Trigonometry, as the Sine of the Complement of the Latitude, is to the Sine of the Declination, so is the Sine of 90 Degrees to the Sine of the Sun's Distance from the East at Rising, and from the West at Setting ; and is always Southerly, when the Declination is South, and Northerly when North. And as much as this Distance differs from that observed by the Instrument, so much is the Variation : And if the Bearing taken by the Instrument be to the Left-hand of that calculated, it is Westerly, otherwise Easterly.

Or it may be found, by an Horizontal Dial, duly seated, without the Sun ; if you stretch a Thread on that Dial's Meridian Line, and the Instrument placed near it, you turn the Index about, till the Telescope is parallel to that Thread ; for then the Bearing shewn by the North-End of the Needle, is the Variation.

Beside the preceding Uses of this Dial, it may, with a very small Addition, be applied in all respects as a *Theodolite*, or *Circumferentor* ; or this Dial may be aptly and easily mounted on a *Theodolite*, and to be taken off at Pleasure.

There is one Inconvenience usually attends the Use of these Instruments, which in this may be remedied : From about an Hour before, to an Hour after Noon, the Passage of the Spot of Light over the Equinoctial, forms with it so acute an Angle, that it is not very easy to observe the Point where it crosses it ;
and

and consequently, the preceding Problems cannot be so exactly performed. And just at Noon, the Thickness of the Brass shades the Slider and Bridge; and so no Observation at all can be made.

In this Case, bring the Beginning of the Degrees to the Index on the Horizontal Part, and let the Hour be taken by the Instrument some Time before, which is remote from Noon, whether before or after, on the Board of the Window of your Study, where you design to use it; the Index all the while pointing to the Beginning of the Degrees. Lay a strait Ruler to touch the Feet mark'd A, A; and by its Edge, draw on the Window Board a strait Line, or make Two Points where that strait Line should be drawn: And then, at any Time that is very near Noon, by laying the Ruler to the Line or Points, bringing the Beginning of the Degrees on the Horizontal Part of the Pedestal to the Index, and applying the Feet A, A, to the Edge of the Ruler, as before; if you rectify the Instrument to the Latitude and Day, you may see the true Time either before or after Noon; and just at Noon, the Middle of the under Part of the Meridian will be shaded by the upper; and consequently the Time of Noon, is known, and determined whether it be before or after Noon.

If you are in a strange Place, and the Time be very near Noon, level the Instrument, and turn it about till the North-End of the Needle points at the Variation, and then

then it is duly placed, and you may work as in the last.

Much more might be said of this Instrument's Use, but my designed Brevity will not permit me to enlarge any farther thereon.





APPENDIX

TO THE

Practical Surveyor.

S E C T. I.

Of a New, Certain, and Expeditious Method of Surveying and Plotting by the Theodolite, as now improved.



IN the Practice of Surveying, it hath hitherto been found very difficult to make a large Parcel of Land, when it came to be laid down in a Map, close exactly with regard both to the Lines and Angles measured, especially if it were mountainous and hilly Ground, nay even a small Quantity of uneven Land has often puzzled those who otherwise thought themselves expert Surveyors. Now this Difficulty

ficulty in closing the Draught, arises chiefly from the following Causes.

First, The not taking Care to place the Plane of the Instrument truly horizontal or level, and which indeed it is almost impossible to do by the Eye alone, especially on the Side of a Hill; and tho' this may by some be thought of little Signification, yet those who have any Knowledge in Geometry, must allow, that very great and unavoidable Errors will arise thereby; for it may be demonstrated, that if the Plate of the Instrument dip but 2 Degrees at right Angles to the Line of Observation, and the Hill descend 10 Degrees, it will cause an Error of 42 Minutes in the Angle, and the Object will be thrown out of its true Place 12 Links in the Distance of 10 Chains; and how great Confusion must this make in Plotting the succeeding Angles which turn thereon as on a Centre? But if so considerable an Error arise by missing the Level only 2 Degrees, nearer than which I believe no one will pretend to place an Instrument by his Eye, what egregious Blunders must the Practisers with the plain Table make, who, when they cannot see thro' the Sights of their Instrument on an Ascent or Descent, do commonly raise, dip, or, as it may be properly said, twist the Plane of their Table more or less out of the Level till they can see their Objects?

Secondly, The not making due Allowance for the Difference between the Lines of Ascent or Descent, and the Horizontal Lines, which are the only Lines that ought to be laid down;
and

and though 'tis a common Practice on the Side of a steep Hill, to double the Chain, and so in ascending to make the Leader hold the middle in his Hand close to the Ground, while the Follower raises the End by the Staff in his Hand, till he judges it to be strained on the Level, and in descending, the Leader elevates the Middle by his Staff in like manner, while the Follower keeps the End close to the Ground; yet a true horizontal Line can hardly be obtained this Way, by reason of the Swaying of the Chain, and the Incertainty of keeping it in its due Place.

Thirdly, The plotting the Angles by removing the Protractor from Station to Station; in doing which, if we consider the Nicety required in laying the Diameter of the Protractor, and the Variation of the Hand in pricking down the Quantity of Degrees and Minutes, and in drawing the Station-Lines, we must allow it to be a very difficult Matter to protract so near as 10 Minutes; whence, if there be a considerable Number of Stations in the Circuit, the Plot will rarely be found to close as it ought, for an Error in any one of the Angles will be communicated to all that follow, and each succeeding Station will be thrown more and more out of its true Place, as it is farther from the Angle where the Error first arose; and though it be a good Way to protract backwards as well as forwards, yet even that will hardly bring it to bear, unless the Errors happen to counterbalance.

The foregoing are the principal Causes that render it difficult to make a correct Map; and they are now entirely obviated by the *New Improved Theodolite*, as made by Mr. HEATH, and the Method of Surveying and Plotting hereafter described.

First, This Instrument hath a Spirit-Level affixed to the Telescope, and another Spirit-Level at right Angles thereto in the Box; by Means of which cross Levels, and the Help of four Screws playing between two Plates in the brass Head of the Staff, the Plate or Limb of the Instrument is readily brought to a true Horizontal Situation.

Secondly, The Telescope having cross Hairs therein, turns on an Arch fix'd on the Index perpendicular to the Plate of the Instrument, the Arch is of the same Radius as the Plate, and the Telescope may be elevated or depress'd thereon quite to a Quadrant, or 90 Degrees. On this Arch are graduated the Degrees of a Circle, which are number'd from the Vertex either Way, with 10, 20, &c. and are cut by an Index under the Telescope, divided after *Nonius's* Way, like those on the Limb of the Instrument. Within the Degrees are two Lines number'd with 10, 20, &c. down to 100, and cut by the Edges of the Index, on the right whereof is grav'd *Elevation*, and on the left *Depression*. These Lines serve to shew the Altitude or Depression of any Object in 100 Parts of the Distance at which the Instrument is planted to take the Observation, and are useful in finding the Height of a Tree

Tree in the measuring of Timber standing ; as also to find the Altitudes of the several Parts of a Building in drawing the perspective Appearance thereof, as hath been before taught. Below these are other Graduations cut by the lower part of the Index, which shew the Difference between the Hypotenuse and Base of any right-angled Triangle, (the Hypotenuse being always supposed to consist of 100 equal Parts) and consequently they give by Inspection the Number of Links to be deducted out of each Chain's length in going up or down any Hill, for reducing the Hypotenusal Lines to Horizontal. There are also plain Sights fixed upon the Telescope to be used in short Distances, and for continuing the same strait Line both Ways from the Instrument, as is necessary to be done in many Cases.

When the Index under the Telescope is set to 00° at the Vertex of the Arch, and the two Bubbles brought to the middle of their Tubes, then the Horizontal Hair in the Telescope cuts an exact Level, and the Plate of the Instrument becomes a true Horizontal Plane ; and if the Intersection of the cross Hairs be set to any Object by moving the Telescope above or below the Level, the Divisions on the Vertical Arch will shew the Elevation or Depression of the Object: Also, when the Telescope is directed to any Object the Instrument may be readily fix'd so firmly in that Direction, by turning a Screw under the Centre, that there can be no danger of its being stirred by removing the Index on the

Plate towards another Object. The Degrees on the Plate are divided so accurately, that though they are cut by three Indices 120° distant from one another, having *Nonius's* Divisions on each, yet the Eye can perceive no Inequality in the Divisions all round the Limb, but whatever Part of a Degree the Index under the Eye-Glass of the Telescope cuts, the same will always be found to be cut by the other two; there is also a small Index that serves to cut the particular Divisions on the Limb to be used for taking the Breadths in drawing the perspective Appearance of any Building. The whole Index, with the Box fixed thereon, turns round on a conical Centre without stirring the Needle, and may be fix'd to any Part of the Limb, by means of a Spring and Screw adapted thereto. In a Word, the entire Instrument is contrived so commodious, portable and strong in all its Parts, that it is allowed to be the best of the Kind ever yet made.

Thirdly, In order to avoid any Error that may arise in taking the Angles in the Field, or from protracting them Angle by Angle, as has heretofore been the universal Custom, let the Surveyor observe this following Method, which for its Readiness as well as Accuracy, will, no doubt, be preferr'd and practised by all who would excel in this Art.

The Instrument being planted at the first Station, fix the Index to 360 Degrees on the Limb, and setting the Plate truly Horizontal, turn it about till the South-End of the Needle hangs over the *Fleur-de-lys*, or 360
in

in the Box, and fix it in that Position by help of the Screw underneath; then discharging the Index, turn that about, and direct the Vertical Hair in the Telescope to cut the second Station; there fix the Index to the Plate again, and the South-End of the Needle will shew the Bearing of the first Line, which will also be cut by the Index on the Limb, and is to be entered in the Field-Book, as before taught. Now when the Instrument is removed and planted at the second Station, observe that the Index hath not been stirr'd, and turning the whole Limb about, direct the Vertical Hair in the Telescope back to cut the first Station, fix the Plate in that Position; then discharging the Index, turn it about till the same Hair cuts the third Station; there fix the Index to the Plate again, and set down the Number of Degrees and Minutes it cuts on the Limb, which Number will at the same time be cut by one End or other of the Needle in the Box, if there be no Mistake in the Observation: Proceed in like manner at the third and all the following Stations, always remembring after you have turn'd the Plate about, and directed the Telescope backwards, to observe that the Index remains fix'd at the Degrees last noted in the Field-Book, so will the Needle be always found to correspond with the Index sufficiently near, to discover and prevent any Error in the Work.

We have here added an Example of Part of the Field-Book of an actual Survey, where-

in the Angles were observed by the Method above described ; and though there were 24 Stations in the Circuit, yet for Proof, the Instrument being planted again at the first Station, and the Telescope directed back to the 24th, the Plate being fix'd in that Position, the Index was discharg'd, and the Telescope directed to the second Station, and then the Index cut the same Number of Degrees as was first set down in the Field-Book.

When there is occasion to return to some former Station, in order to go off from thence for the closing some particular Part, as in the following Example, we return to Station 23. Enter the Number of such Station again in the Field-Book, with a small Figure at the Head of it, denoting how often the Instrument hath been planted at that Station, thus 23² denotes the second Time of planting the Instrument at Station 23 ; then consider from which Station you look'd forwards to the present Station 23, which was Station 22, seek in the Field-Book the Bearing of the Line between the Stations 22 and 23 ; and fix the Index to that Number on the Limb ; then turning the Plate about, direct the Telescope back to the former Station 22, fix the Plate in that Position, and discharging the Index, direct the Telescope forwards to the next Station, and thence proceed as before ; so will the Needle be always found to be a sure Checque on the Limb, tho' the Observations do not depend thereon.

Note,

Note, The Letters affixed to the Numbers of the Stations in the following Field-Book, are not to be used in Practice, being here added only for the more easy referring to the Plot, in describing the new Method of laying down.



FIELD-BOOK of Part of the Manor of R, &c.

Remarks, Left.	Offsets Left.	⊙ s Bearings Lengths.	Offsets Right.	Remarks, Right.
		⊙ 1 (A)	- -	Upon Warley Common.
Bearing - - - -	- -	43 : 20	- -	N° Ely
Hedgebutts to Kiln Wood	20	11		
Against Kiln Wood - -	27	59		
Hedge to ditto - - -	31	165		
		⊙ 2 (B)		
L -  - - -	- -	204 : 40		
	30	175		
	15	280		
	30	400		
	21	560		
Hedgebutts to Furzfield	14	746		
		766		
		⊙ 3 (C)		
Against Furzfield - -		17 : 12		
	9	50		
	1	100		
	3	200		
	21	365		
		446		
Hedgebutts to Furzfield	27	470		
against upper Poundfield	30	520		
		⊙ 4 (D)		
		195 : 50		
Hedgebutts to Woods Ga.	46	140		
Depth of the Gard. 216	41	255		
Pound begins, and Fence-	48	500		
butts ends	46	527		
		560		

⊙ for closing Furzfield and
entrance of the Lane
to Brentwood.

		⊙ 5 (E)	
		268:20	
L ^r s Pound - - -	{ 15	50	× Gate into Pound Lane.
	{ 7	65	37 to Gate into lower Pound field.
Woods House 30 deep	{ 35	97	
	{ 20	114	
L ^r of Woods Garden 113 deep, and Hedge- buts to upper Pound- field	24	165	
		225	75 Hedgebuts to Lower Poundfield against Pondfield.
		272	
		300	32
Gate - - - - -	20	330	20
	28	350	
		383	20
		444	23 Hedgebuts to Cowhouse- field.
	15	465	
	12	483	25
		⊙ 6 (F)	
		107:50	
Gate - - - - -	6	58	26 Gate.
Hedgebuts to Upper Poundfield against little Boggyfield	12	155	
		200	29 Hedgebuts to Cowhouse- field against the Hop- pit.
Gate - - - - -	42	222	16
	6	238	- - Gate.
		300	22
		⊙ 7 (G)	
		332:15	
Lane returns - - -	15	26	13
		170	6
	21	186	
		200	⊙ for the Return N° 32.
L ^r against Gravel-pit- field	7	247	10 × Gate into Moor's Barn- field.
Hedge to Barnfield - -	7	267	

Ponds begin in Gravel-pit field

Ponds end - - - -
Gap - - - -
Fence changes to Gravel-pit field.

Gate - - - -

From bye © at 330 in Line 11, 12.

310 to ©
N^o 11.
50 90
330 23
388
100 6
280 0
315 30
351
130 4
170 6
266 58
375 69
440 0
10 480
to Kiln 195 494
Field 120 550
568
X Hedge & Brook into Cumbers's
X billy Field Hedge
720 to © 13

	© 8 (H)	
	166:20	
12	190	
30	250	
39	265	
30	300	
	379	
	© 9 (I)	
	324:35	
40	27	
	118	
60	200	
58	317	
9	457	
2	535	
9	586	
	698	
	© 10 (K)	
	40:50	
	20	34
	165	45
	380	12
	520	24
	744	58
	791	
	© 11 (L)	
	225:45	
	67	64
	84	75
	250	75
	330	bye ©
	340	X into
	473	27
	493	
	505	

X Gravel-pit field Hedge into Ditto, against Home field Hedge to Ditto.

Hedgebutts to Dung field Gate.

for the Alder Ground. X into Alder Ground.

X Hedge and Brook into Cumbers's Lane.

		⊙12(M)	
		355:50	
To the Brook - - -	24	90	
	46	157	
		178	III to Cumbers's Garden Hedge.
	42	236	
	62	275	
		308	x into Cumbers's Alder Ground
			45 to Gate + 60 to Lr Homsted.
		347	51 to Lr Hillyfield Hedge.
75		357	
75		427	
		480	x into Hillyfield.
		535	
		⊙13(N)	
		165:25	
To Hillyfield Hedge - -	43	77	
Against Alder Ground	42	100	
	50	117	
	60	170	
	53	267	
To Alder Hedge 45 +	45	312	
	11	396	
To Al. hedge 81 + Corn.	7	446	x hilly field Hedge into Boggy-field.
		489	
		⊙14(O)	
		319:25	
To Alders - - -	30	13	
To Kilnfield Hedge - -	128	40	
To Alders - - -	25	120	
To hunting Gate 55 +	30	155	
Point of the Island 59 +	30	200	
		229	

		⊙ 15 (P)	
		179:55	
Against Island - - -	43	8	
Fence to ditto - - -	25	75	
	21	237	Bogs.
	37	345	
	25	464	
	16	484	
		⊙ 16 (Q)	
		33:20	
	17	50	
Corner - - - -	13	188	
		⊙ 17 (R)	
		280:50	
Hedge to Boggyfield -	15	00	
Woodland ends - - -	18	79	
	15	148	
		177	
		⊙ 18 (S)	
		347:50	
		19	x Boggyfield Hedge to
Against Acre Bit - -	16	240	Broomfield.
		388	
		⊙ 19 (1)	
		27:25	
		74	x Acre Bit Hedge to dit.
To Alders - - -	40	150	
To Hedge - - -	57	194	
		241	
		⊙ 20 (V)	
		256:35	
To Hedge 15 + - -	15	00	
25 + - -	10	100	

To Hedge - - -	15	198	x	Acce Bit-hedge into lit-
Against woody Ground	19	260		tle Broomfield.
Hedge to lit. Broomfd.	50	383		
		⊙ ²¹ (W)		
		90:30		
	60	72		
Bogs - - - -	70	163		
	75	340		
		395		
		⊙ ²² (X)		
		290:10		
Against Kilnfield Gate - - -	49	20		
		176		
		⊙ ²³ (Y)		
		104:00		
Corner - - - - 5 +	14	35		
Against Kiln Wood	12	103		
Hedge to ditto		183		
		⊙ ²⁴ (Z)		
		311:10		
	5	00		
	15	63		
	6	163		
	8	243	x	Hedge into Warley Com.
		263		To ⊙ 1 where the
				⊥ from the last Bear-
				ing to ⊙ 2 was found
				to be 43°:20' as at
				first setting out.
Return to - - -	⊙	23 ² (Y)		against Kilnfield Gate.
		190:10		
		27	x	Gate into woody Ground
				in Kilnfield.
		100	35x	out of Wood into field
		180	29	agst Kilnwd H. to dit.

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Return to - - - -

	324	12	
	465	26	
	510	55	
	580	72	
	630	55	
	690		
⊙25(a)	84:40		
	37	18	into Boggy Wood Hedge
	80	15	to ditto.
	246	23	
⊙26(b)	284:40		
	50	33	
	170	50	
	209	x	into Furzfield Hedge to dit.
	224	53	
⊙27(c)	105:30		
	100	27	
	190		to Corner close Kiln Wood.
⊙	25 ² (a)	- - -	in Kilnfield.
	349:30		
	30	33	against Boggy Wood.
	90	15	
	280	37	
	396	- - -	Hedgebutts to little Boggyfield.
	424		
⊙28(d)	252:50		
	34	x	Boggyfield Hedge into
	120	45	ditto.
	200	42	
	291		

	⊙ 29 (e)		
	79:30		
	100	35	
'Strait Hedge to Pound-lane	161	×	Upper Poundfield Hedge into ditto.
	190		
	⊙ 30 (f)		
	325:12		
	50	28	
	158	×	Furzfield Hedge into dis.
	187		
	⊙ 31 (g)		
	184:00		
	35	30	Corner.
	65	45	
	300	25	
	428	to ⊙	27 close Boggy Wood.
Return to - - -	⊙ 31 ² (g)		
	100	80	
	314	to ⊙	for close Furzfield in Line 3, 4.
Ret. to ⊙ for the Return of Pound-lane at 200, in Line 7, 8	⊙ 32 (h)		against Gravel-pit field Hedge to ditto.
	68:20		
	147	29	
	200	- -	Alders begin.
Hedgebutts to little Boggyfield	11	212	25 × Gate into Kilnfield.
		237	- - Alders end.
		306	
	⊙ 33 (i)		
	172:08		
Stile in Boggyfield Hed.	110	118	
	78	390	Pond.
	56	454	
	28	574	
	43	615	
	670	to ⊙	28 close little Boggyfield.

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Return to - - -

⊙	33 ² (i)	
	319:55	
	20	
	40	69
	173	40
	200	0
	320	11
	400	45
	500	45
	535	25
	600	27
	629	
⊙	34(k)	
	232:05	
	43	5
	106	5
	144	
⊙	35(l)	
	141:35	
	56	6
	627	10
⊙	23 ³ (Y)	
	161:30	
	170	
	250	
	380	
	412	
⊙	36(m)	
	350:05	
	72	70
	68	230
	15	300
	15	595
		633

x Gravel-pit-field Hedge
into ditto against Ald.

To Kilnfield - - -

Return to - - -

Against Woody Ground

Close Alders.

n Broomfield against
Kilnfield Gate.

x out of Wood into Kiln-
field.

Corner - - -

Kilnfield.

	⊙ 37 (n)	
	76:10	
90	170	
	458	
	⊙ 38 (o)	
	181:48	
Passage to Island - -	30	50
		165
	45	256
	120	390
		455
	90	520
		570
	50	594
	⊙ 38 ² (o)	
Return to - - -		357:00
		371
		451
		473
	⊙ 39 (p)	
		235:55
	348	15
		474
		519
		674
		707
		765
		765

X into Woody Ground.

X Rill.

85 X into Island.

80

70 Corner.

To the Top of the Island.

X Kilnfield Fence into rough Ground.

X Gravel-pit field Hedge into ditto.

Railsbutt + 61 to rough Ground Fence.

Kilnhouse 33 deep + 35 to Fence.

Workhouse 65 deep.

32, 33 close Kilnfield.

Close Gravel-pit field

N

Now

Now to protract the foregoing Observations through the Middle of the Paper designed for the Draught, draw the Right Line *NS* for a Meridian, and therein chuse a convenient Point *C*, to which lay the Centre of a circular Protractor, the Diameter coinciding with the Line *NS*, and the 360, or Beginning of the Degrees being towards *N* the North, fix the Protractor in that Position by laying a Weight thereon, or pinning it down; then on the Circumference of the Protractor prick down the several Bearings noted in the *Field-Book*, numbring from the North Eastwards, or towards the Right-hand all round, and to each Point affix the Number of the Station to which it belongs.

Chuse a convenient Place on the Paper for the first Station, as at *A*, and laying the Edge of a parallel Ruler to the Centre *C*, and the Point marked 1, open the Ruler till the Edge cuts the Point *A*, and thereby draw an occult Line parallel to *CA*, on which set off the first Length (165) from *A* to *B*, the 2d Station; then laying the parallel Ruler to *C* and the Point 2, transfer it to *B*, and thereby draw an occult Line, on which set off the second Distance (766) from *B* to *C*, the third Station: Again, lay the parallel Ruler to *C* and the Point 3, transfer it to *C*, through which draw an occult Line, and thereon set the third Distance (520) from *C* to *D* the fourth Station. Proceed in like Manner all round, and if the Work be true, the last Line will
pass

pass through the first Point; but if it doth not, and the Error arises by mistaking a whole Chain or so, it may readily be discovered in which Line it was committed by observing whether the last Point fall short of, or beyond, or above, or below the first Point with which it ought to coincide.

The only seeming Difficulty that can arise in drawing the Station Lines by this Method, will be to distinguish between an inside and an outside Angle, though this can seldom be any Obstacle to the Surveyor who took the Dimensions, and who by the Idea he has of the Land, will, for the most part, remember whether he turn'd off to the Right or Left at such or such a Station; yet, if he should at any time doubt, as it may perhaps happen when he hath several Days Work to protract, and multitude of short Stations therein: Or, if any Person who never saw the Land, should attempt to draw it out by the *Field-Book*, and find himself at a Loss about the Quantity of an Angle; then let him subtract the Bearing at the next preceding Station, from the Bearing at the present Station in question, increased by 360, if Subtraction cannot otherwise be made, and the Remainder gives the present Angle; which if it be less than 180° , shews that the Line flowing from the Station, must be drawn inwards, but if more, outwards. Thus at $\odot$ 17 noted with R, it might be doubted, whether the Line from thence should be drawn inwards towards *f*; or outwards towards *S*; to solve which from the

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Bearing at the present $\odot$ 17, $280^{\circ}:50'$, subtract the Bearing at the last $\odot$ 16, $33^{\circ}:20'$, and the Remainder $247^{\circ}:30'$ being greater than $180:00$, shews that the Line must be drawn outwards towards S, the same Doubt might also arise at $\odot$ 18 (S), but if from the Bearing at $\odot$ 18, $347^{\circ}:50'$, we subtract the Bearing at the last $\odot$ 17, $280^{\circ}:50'$, the Remainder $67^{\circ}:00'$ shews it to be an inside Angle: Again, at $\odot$ 19 (T) the Bearing is $27^{\circ}:25'$, to which add 360° , and subtract the Bearing at the last $\odot$ 18, $347^{\circ}:50'$, and the Remainder $39^{\circ}:35'$ shews the present Angle to be an inside Angle, and very acute.

When the Draught is so large, that all the Stations cannot conveniently be laid down about one Centre, the first Meridian Line may be prolonged, or another drawn parallel thereto, in which the Surveyor may make Choice of a new Centre where he shall think most proper, and round this he may place his remaining Stations in like Manner as before described; and thus, he may chuse as many Centres as he shall find necessary, but the fewer he can dispense with, the better.

Moreover, the Bearings may be laid down by a Semicircular Protractor number'd, as 'tis commonly done, with a double Row of Figures to 360° , which some may rather chuse to use, because the Limb thereof may be turned wholly towards the Light, that so the Divisions may be more advantageously seen; but considering the Edge of a Protractor is always made very thin, there can be no Advantage

vantage gained thereby; besides the Circular *One* is to be preferr'd in that it hath twice the Room, and consequently, when there is Occasion for laying down a great Number of Observations about the same Centre, they will be less liable to Confusion. Again, the Degrees on the Limb of the Instrument and in the Box, may be number'd only to 180, and then begin again with 10, 20, &c. to 180 more, by which means that End of the Needle which is next the Eye, will always cut the same Division in the Box as the Index doth on the Limb, and there will never be Occasion to enter a Bearing greater than 180° in the *Field-Book*; so a Semicircular Protractor number'd with a single Row of Figures, will serve to plot all the Observations; but then there will be this great Disadvantage (as well as the foregoing in point of Room) that, should the Surveyor forget whether any Angle was more or less than 180° , he could not readily discover which to make use of; and should a Person, who had never seen the Land, go about to protract the Work from such a *Field-Book* alone, he must be gravel'd at every Station where the Angle approaches near 90° or 270° , as not having any Means whereby to discover on which Side it is to be formed, tho' this Doubt may in some measure be prevented by noting the Angle in the Field by the Mark $\angle$, or 7, according as it is within or without; yet should the Surveyor put down a wrong Mark, or forget to enter any (which may easily happen when a Multitude

of Observations are to be taken, and the Weather proves untoward) in such Case a great deal of Time may be spent before it can be ascertained whether the Angle be Internal or External, which is very readily known in the former Method ; therefore *That* must be the most preferable, since it can never be subject to any such Inconvenience : And the Practice thereof will be found so very easy to any Person that understands the foregoing Part of this Book, that a farther Explanation would be altogether needless, we shall therefore proceed to shew in





S E C T. II.

How to reduce any irregular Figure into a Triangle, whereby the Content of any irregular Piece of Land may be cast up much sooner and more accurately than by the common Method of dividing it into Trapezia and Triangles.



THE Practice hereof is much the same with what hath been deliver'd in *Sett. IV.* concerning the Reduction of the irregular Curvatures in Hedges to strait Lines, and depends wholly on the 37th Prop. of the 1st Book of *Euclid*, where it is demonstrated, that Triangles standing on the same Base, and being between the same Parallels are equal one to the other.

E X A M P L E I.

Let it be required to reduce the Trapezium ABCD, *Fig. 1.* into a Triangle, having its Vertex at the Angle A. Plate II.

N 4

Produce

Produce the Base BC, and draw the Diagonal AC, thro' D draw DE parallel to AC, till it meet BC in E, join AE and ABE will be the Triangle required.

The second Figure shews how in like Manner to reduce a Trapezium having a re-entring Angle.

EXAMPLE II.

Let it be required to reduce the Trapezium ABCD, *Fig. 3.* to a Triangle whose Vertex shall be at the Point E in one of the Sides AB.

Join BE and CE, draw AF parallel to BE, and DG parallel to CE, till they meet the Base BC produced in F and G, draw the Lines EF and EG, and the $\triangle$ FEG will be equal to the Trapezium given.

EXAMPLE III.

Let it be required to reduce the Pentagon ABCDE, *Fig. 4.* to a Triangle, having its Vertex at the Angle A.

Produce the Base CD both Ways, and draw the Diagonals AC, AD: through B draw BF parallel to AC to cut CD in F, and through E draw EG parallel to AD to cut CD in G, join AF and AG, and AFG will be the Triangle sought.

EXAMPLE IV.

Let it be required to make a Triangle equal to the irregular Hexagon ABCDEF, and let the Side AB be one Side of the $\triangle$.

Produce

Produce the Side DE, join AE, and parallel thereto thro' F draw FH to meet DE in H, join BD, and parallel thereto draw CG to meet DE in G; by B and G draw out a right Line, join AG, and parallel thereto thro' H draw HI to meet BG produced in I, draw AI, and ABI, will be the $\triangle$ required.

EXAMPLE V.

To reduce any right-lined Figure given into a Triangle; as suppose the seven-sided Figure ABCDEFG, *Fig. 6.*

First draw BD, and parallel thereto CK; then if BK be drawn, it will cut off from the Figure the $\triangle$ DKS, and will take in the $\triangle$ BCS equal thereto, and the Side BK will supply the Use of the two Sides BC and CD. Also, draw GE, and parallel thereto FL; then if GL be drawn, it will cut off from the Figure the $\triangle$ LRE, and take in the Triangle GRF equal thereto, and the Side GL will supply the Use of the other two Sides GF and FE, and the whole Plot ABCDEFG consisting of seven Sides, is reduced to the five-sided Figure ABKLG, yet still retaining the same Quantity. Now to reduce this Plot into a $\triangle$, work in all respects as in the *Third Example*. First, produce the Base both Ways, then draw the Lines AK and AL; and parallel to them the Lines BH and GM, cutting DE extended in H and M. Lastly, draw the Lines AH, AM, and they will constitute

tute the $\triangle A H M$ equal to the right-lined Figure given.

In like manner may any other irregular Figure of ever so many Sides be reduced to a $\triangle$, and that very readily by using a parallel Ruler, whereby we avoid drawing the unnecessary Lines, only marking their Intersections on the Base. Thus in *Fig. 7.* lay the Edge of a parallel Ruler to the Points B and D, then open the Rule till the same Edge cuts the Point C, and mark where it intersects the Base D E at k, lay the Ruler again to the Points k and A, transfer it to B, and mark its Intersection on the Base at h; then draw A h, which will be one Side of the Triangle sought. Again, laying the Ruler to E and G, transfer it to F, and mark the Intersection on the Base at l, lay the Ruler to l and A, and mark where it intersects the Base prolonged at m. Lastly, draw A m, and the Triangle A h m will be equal to the seven-sided Figure as was required.

We have added in *Plate 3*, a Figure shewing how the Contents of the foregoing Example of Part of an actual Survey was cast up, and have likewise here subjoined the Dimensions and Calculations, whereby may be seen that, notwithstanding there are 10 several Pieces measured separately; yet, when the whole Plot was reduced to the Trapezium M N O P equal thereto, the Content of such Trapezium was found not to differ from the Sum of the several Contents

†

by

by half a Pole, a Confirmation of the Truth surprizingly near.

Gravel-pit Field with
the small Parcel of
Alders in the middle
of it reduced to the
 $\triangle abc$.

The Base ab } 1758
measur'd - - }

The Perpendi- } 1078
cular from c }

14064
12306
17580
18|9|5124

Area per } A. R. P.
Sect. 4. } 9 : 1 : 36

Subst. Ald. 0 : 2 : 14

Area of } 8 : 3 : 22
the Field }

The Alder Wood on
the West-side of Gra-
vel-pit Field reduced
to the $\triangle gbi$.

Perpendicular } 598
from b - - }

Base gi - - - 805

2990
47840
4|8|1390
A. R. P.

Content - 2 : 1 : 25

The small Parcel of
Alders in the middle
of Gravel-pit Field
reduced to the $\triangle$
 def .

The Base df - 655

Perpendicular } 179
from e - - }

5895
4585
655
1|1|7245

Content - A. R. P.
0 : 2 : 14

Kiln Field reduced to
the $\triangle klm$.

The Base lm - 1825

Perpendicular } 1002
from k - - }

3650
182500
18|2|8650

Content - A. R. P.
9 : 0 : 23

Woody

Woody Ground in
Kiln Field with the
Island reduced to the
Trapezium $n o p q$.

The Diagon. np 1120

⊥ from q 530 } Sum

⊥ from o 410 } 940

44800

1008

10|5|2800

A. R. P.

Content - 5 : 1 : 02

Upper Pound Field
reduced to the $\triangle$
 $w x y$.

The Base $w x$ - 930

⊥ from y - - 464

3720

558

372

43|1520

A. R. P.

Content - 2 : 0 : 25

Boggy Wood reduced
to the $\triangle D E s$.

The Base DE 955

⊥ from s - - - 480

76400

3820

4|5|8400

A. R. P.

Content - 2 : 1 : 07

Little Boggy Field
reduced to the Tra-
pezium $r s t u$.

The Diagon. rt - 752

⊥ from s - 380 } 680

⊥ from u - 300 }

60160

4512

5|1|1360

A. R. P.

Content - 2 : 2 : 09

Woods House and
Garden reduced to
the $\triangle A B C$.

The Base BC - 375

Perpend. from A 197

2625

3375

375

17|3875

A. R. P.

Content - 0 : 1 : 19

Furz Field reduced to
the $\triangle F G H$.

The Base GH - 929

⊥ from F - - - 336

5574

2784

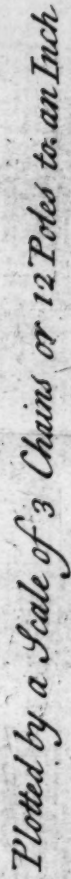
2787

3|1|2144

A. R. P.

Content - 1 : 2 : 10

Kiln



Appendix. Plate II.

Fig. 1.



Fig. 2.

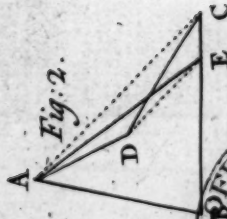


Fig. 3.

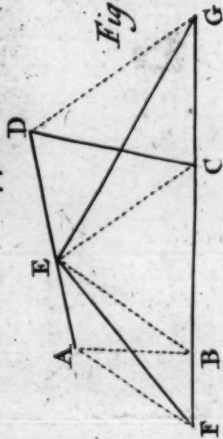


Fig. 4.

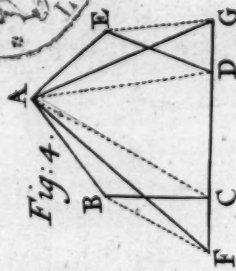


Fig. 5.

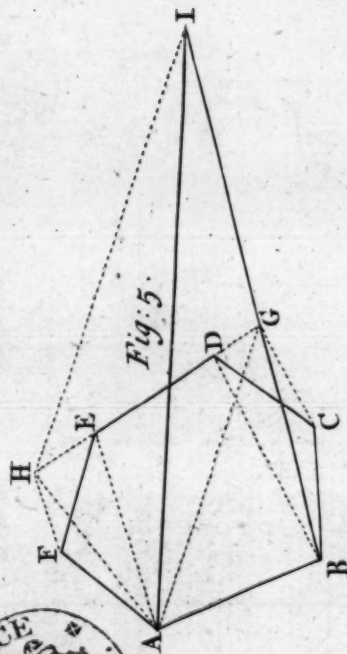


Fig. 6.

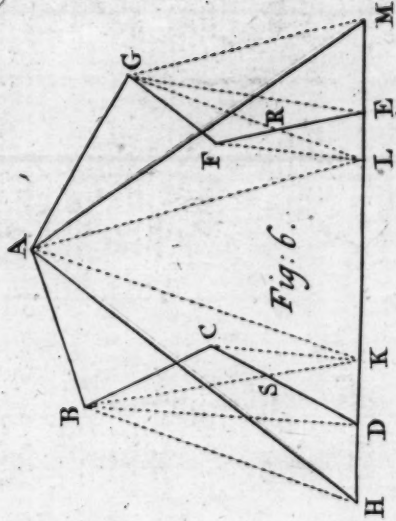
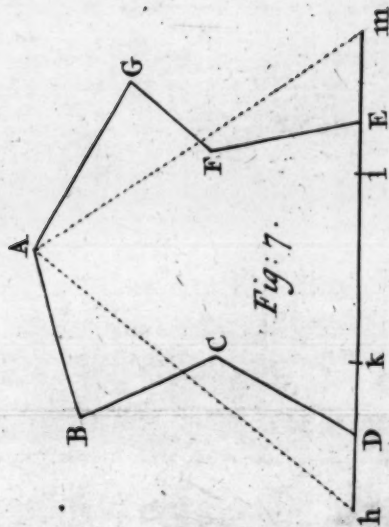
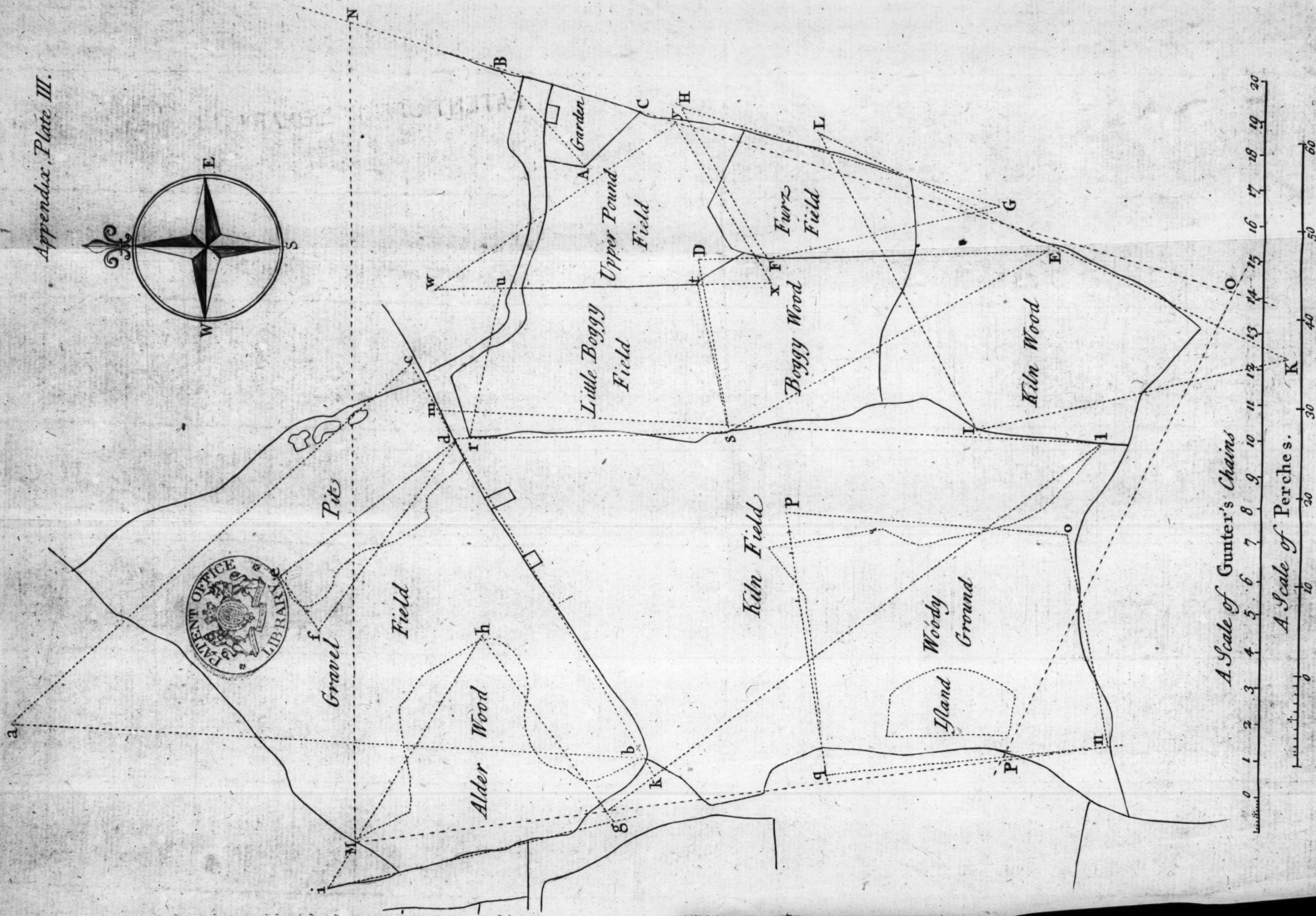


Fig. 7.





Kiln Wood reduced
to the Δ I K L.

The Base K L - 1441

Perpendic. from I 550

72050

7205

7|9|2550

A. R. P.

Content - 3 : 3 : 34

The whole Plot re-
duced to the Trape-
zium M N O P.

Perpendicular } 1963
from N - -

Ditto from P - 770

Sum - 2733

Diagonal M O - 2868

21864

16398

21864

5466

78|3|8244

A. R. P.

Content - 39 : 0 : 30
as on the Right.

The CONTENTS.

Gravel-pit Field } A. R. P.
with the Al- } 9 : 1 : 36
ders - - - }

Alder Wood - - 2 : 1 : 25

Kiln Field - - - 9 : 0 : 23

Woody Ground - 5 : 1 : 02

Little Boggy Field 2 : 2 : 09

Upper Pound Field 2 : 0 : 25

Woods House and } 0 : 1 : 19
Garden - - - }

Boggy Wood - - 2 : 1 : 07

Furz Field - - 1 : 2 : 10

Kiln Wood - - 3 : 3 : 34



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